HORIZONTAL TECHNOLOGIES
INCORPORATED

Providing Innovative Solutions to Subsurface Environmental Challenges

205315

7/22/97

July 22, 1997

Ms. Sherry Bianchin
U.S. E.P.A.
Mail Code SR-6J
77 West Jackson
Chicago, IL 60604

Dear Sherry:

Included is the information about our technologies and some videos showing the Polywall in action. We are required by our contract not to mention the ACS Site by name, but the video labeled "Midwest Superfund Site" is the ACS Site.

The pictures show some good people having a nice time after a tough job was completed.

I do appreciate your help and will look forward to hearing from you after you review the information. I will be available to make a presentation at your next regional meeting with your colleagues. Please let me know.

Sincerely,

Donald R. Justice
President

DRJ/jm

Encl.

4767 Pine Island Rd. N.W., Matlacha, Florida 33993
941/283-5640 Fax: 941/283-2222

An Introduction to Trenched Horizontal Wells for Water Supply, Linear Contaminant Remediation Systems and the Polywall Barrier System

Presented by:

Horizontal Technologies, Inc.
4767 Pine Island Road NW
Matlacha, FL
941-283-5640

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7/22/97

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HORIZONTAL WELLS

OUR NEW ADDRESS IS:
HORIZONTAL TECHNOLOGIES, INC.
4767 Pine Island Rd., NW
Matlacha, Florida 33993
Phone: (941) 283-5640 • Fax: (941) 283-2222

- Primary irrigation for citrus and other agricultural needs.
- Primary source for irrigation of golf courses.
- Control of lake water levels.
- Wetland mitigation.
- Primary and secondary source for public water supply.
- Primary and secondary source for fire protection.
- Recovery and reuse of impounded waste water effluents.
- Aquifer recharge and recovery systems for reuse water.
- Supplement water supplies for reuse systems.
- Hazardous and contaminated water recovery and remedial recharge systems.
- Tail water recovery
- Beach stabilization systems.
- Landfill leachate systems.
- Additional applications are available to satisfy specific site requirements.

A UNIQUE GROUNDWATER RECOVERY SYSTEM.

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Horizontal Dewatering Systems, Inc. is pleased to present a new and unique system that takes advantage of shallow surface aquifers as a primary or supplemental water source for golf courses, agriculture and other irrigation needs.

Horizontal

Horizontal
Dewatering
Systems, Inc.

Wells...

offers the opportunity to capture, recover and recirculate surficial groundwater using this water for the following:

- Primary irrigation for citrus and other agricultural needs.
- Primary source for irrigation of golf courses.
- Control of lake water levels.
- Wetland mitigation.
- Primary and secondary source for public water supply.
- Primary and secondary source for fire protection.
- Recovery and reuse of impounded waste water effluents.
- Aquifer recharge and recovery systems for reuse water.
- Supplement water supplies for reuse systems.
- Hazardous and contaminated water recovery and remedial recharge systems.
- Tail water recovery
- Beach stabilization systems.
- Landfill leachate systems.
- Additional applications are available to satisfy specific site requirements.

We have developed a Horizontal
will allow you to tap the reservo
surficial water.

Most of Florida lands have be
groundwater tables, and these gr
been inaccessible as a continued
primary irrigation source becaus
vertical wells that would have to
some meaningful amount of tha
new, patented Horizontal Well sy

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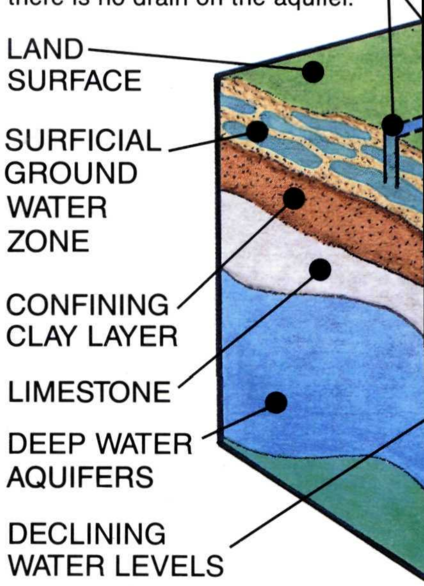
HORIZONTAL WELLS

Surficial water is a currently untappec
By using only surficial water for irriga
there is no drain on the aquifer.



UPWELLING

Pumping from vertical well fields
reduces pressure of the deep water a
directly below. As the fresh water is dr
this deep water aquifer, saltwater push
contaminating the aquifer.

Completed installation paralleling fairway of an existing golf course.

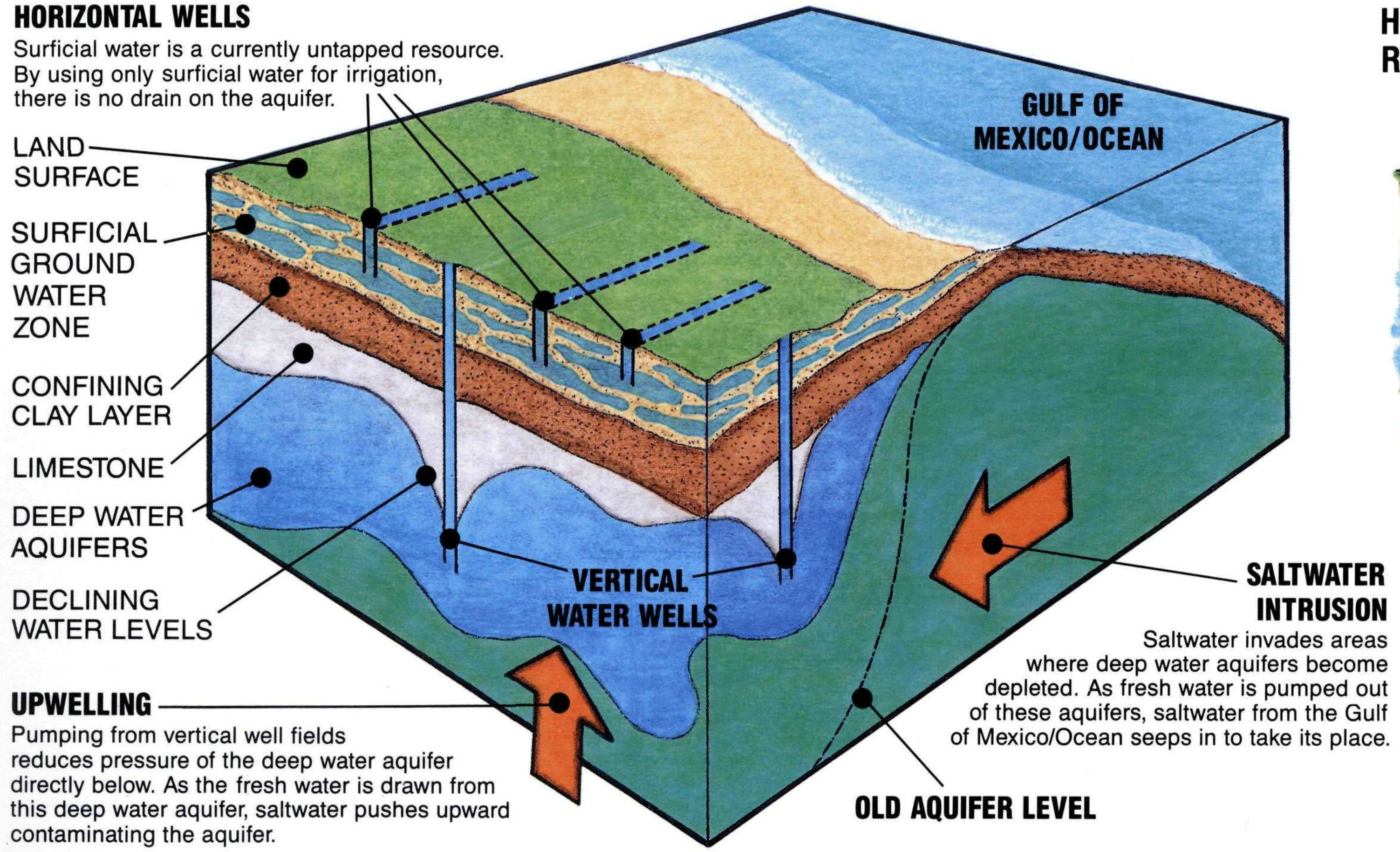
Initial installation of Horizontal Wells allows fo
use of ground waters which are directly recharg
thereby minimizing the "runoff" and adding to t

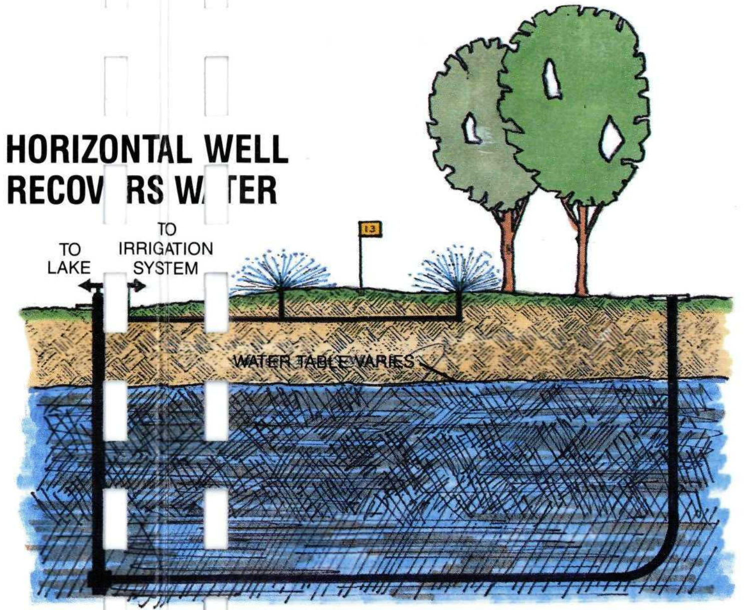
We have developed a Horizontal Well System that will allow you to tap the reservoir of below ground surficial water.

Most of Florida lands have beneath them, high groundwater tables, and these groundwater tables have been inaccessible as a continued resource for a primary irrigation source because of the number of vertical wells that would have to be installed to obtain some meaningful amount of that groundwater. Our new, patented Horizontal Well system lets you tap this heretofore unused resource without drawing water from Florida's hard-pressed deep water aquifers.

For every acre foot of ground that is below Florida's groundwater table, there is as much as 20,000 to 30,000 gallons of water in that one acre, one foot deep. Hence, one acre with a water table of 15 feet of depth at 30,000 gallons per foot would yield approximately 450,000 gallons of water that can now be used as an irrigation source with recycling into that underground surface reservoir economically.

HYDROGEOLOGICAL PROFILE OF FLORIDA





Our new technology enables you to tap the tremendous reservoir of groundwater present beneath your grove land.

This patented system captures the surficial groundwater for grove irrigation and recycles what fertilizers and pesticides are present in this surface ground water, eliminating the need for expensive filtration.

The system should also eliminate the chloride buildup in your soil. The Horizontal Well system will flush and recycle with surficial water eventually removing salt buildup.

Test pumping the Orange Grove installation.

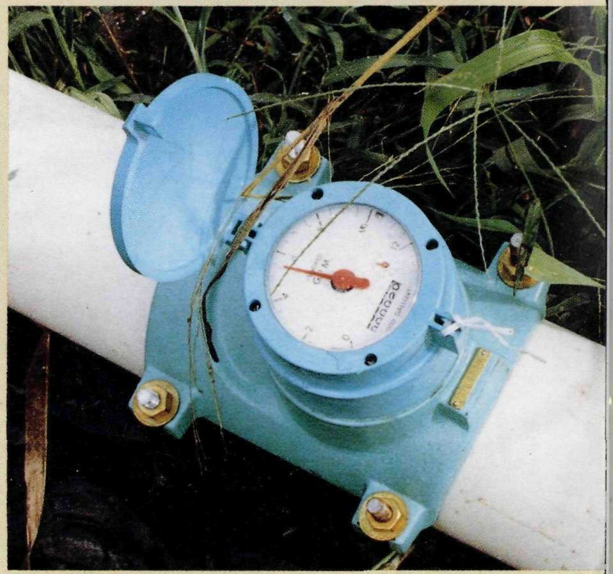
We recover and reuse only the surficial groundwater and the use of this untapped resource is now made possible by HDSI's Patented system.

The benefits and applications of Horizontal Wells are many. Please contact HDSI, P.O. Box 150820, Cape Coral, Florida 33915 for additional information and specifications.

813-995-8777
WATS 800-940-1128
FAX 813-995-8465

Initial installation of Horizontal Wells allows for increasing the capture and beneficial use of ground waters which are directly recharged by surface waters and/or rainfall, thereby minimizing the "runoff" and adding to the ability to provide enhanced retention.

After initial testing our permitting department will assist you or your engineer in obtaining appropriate water use permits.



Test umping a grove installation.

HORIZONTAL TECHNOLOGIES, INCORPORATED

STATEMENT OF QUALIFICATIONS

Introduction

Horizontal Technologies Incorporated (HTI) is the leading provider of Trenched Horizontal Systems in the United States. The company is a unique blend of professional, technical and field experienced personnel combined with innovative proprietary technologies and systems. This unique combination of talent and technology is completely focused on solving problems related to the control, recovery and utilization of ground water and the remediation of the subsurface environment.

The Company has utilized its experience to develop Trenched Horizontal Well technology into the unique Linear Contaminate Remediation System (LCRS) and POLYWALL Barrier System. These systems provide our customers with proven, cost effective approaches for control and remediation of the subsurface environment. As of January 1996, over 2 million feet of Trenched Horizontal Wells have been installed in various applications.

The development of these technologies and system applications represents a revolutionary approach to subsurface environmental control. It has been accomplished through the dedication and experience of the HTI personnel drawing on years of technology development and installation under a variety of project conditions. The people of HTI take pride in assuring that each job is done right, on time and in a professional manner.

Project after project has demonstrated that the application of HTI's technology through professional design, installation and operation of site specific systems can increase the efficiency of ground water and contaminant recovery, reduce remediation time and control vertical and horizontal contaminant movement.

History of the Company

HTI has been installing Trenched Horizontal Well systems in various forms since 1987. These technologies draw on the composite 100+ years of proven success its developer and his associates have had in ground water control and the underground construction industry. HTI's initial efforts were directed at developing a cost effective water recovery and reuse system for agriculture and water table control for the construction industry. The process of using Trenched Horizontal Wells for irrigation, at the time of its introduction in Florida, was revolutionary. HTI's Horizontal Well division has installed over 100,000 feet of Trenched Horizontal Wells for this purpose.

Early in HTI's history it became apparent that the installation of Trenched Horizontal Wells had many applications. There is an increasing demand by owners, designers and regulatory agencies for technology that results in fast, efficient and cost-effective recovery of ground water and remediation of contaminated sites.

From that beginning the technology evolved into the Linear Contaminant Remediation System (LCRS) and the POLYWALL Barrier System. These proprietary technologies have been used successfully on more than 90 remediation projects..

Description of the Technology

The installation of HTI's systems is accomplished using custom designed and manufactured equipment. This equipment is built in Florida using both standard and proprietary componentry. The trenching and delivery operation cuts a nominal 14" wide trench and in one pass installs a vertical riser, horizontal well screen and redeposits the excavated material in the trench. Currently the maximum depth capability of the equipment is approximately 32 feet, although greater depths will be possible in the near future as new machines come on line. Benching techniques have provided successful installations to 50 feet below ground surface.

The vertical riser can be from 6 inches to 12 inches in diameter, and while usually PVC, can be made of High Density Polyethylene (HDPE) or stainless steel as required. The Horizontal Well screen consists of a 5, 6 or 8 inch diameter corrugated HDPE pipe that is manufactured to withstand the application of a vacuum to the pipe at design installation depths. The HDPE pipe is slotted on the inside of the corrugations and is covered with a two ply 420 micron polyester filter fabric. Other filter materials can be used as required. Flexible stainless steel screen or treatment media is also available.

HTI also has the ability to install a specified backfill or media, which typically consists of sand or gravel in specific gradations, in a one step process while installing the Horizontal Well screen. The media is introduced through a delivery mechanism attached to the trenching boom. The system is flexible enough to allow the installation of the filter media from the trench bottom to the surface or to whatever depth is required.

HTI's proprietary POLYWALL Barrier System uses custom designed and manufactured equipment to install a continuous vertical sheet of HDPE. The HDPE may be installed in thicknesses of 40-100 mil. The use of a high strength watertight seal allows installations of any length or configuration to be put in place.

Applications

Linear Contaminant Remediation System (LCRS)

HTI's Linear Contaminant Remediation System (LCRS) is a site specific proprietary configuration that replaces conventional vertical well systems with a series of Trenched Horizontal Wells on a gradient across a plume of contamination. The wells can be accurately installed at predetermined depths utilizing a laser leveling system to minimize area containment and the amount of ground water removal, thus reducing the treatment volume. Contaminated liquids are recovered in higher concentrations.

Case histories of actual installations and solute transport simulations have shown significant efficiencies (reduced cleanup times and required volume of water pumped) in the remediation of shallow plumes of contaminants, such as light non-aqueous phase liquids. These efficiencies resulted in reduced up front capital cost in many instances and, in all instances, have reduced operation and maintenance costs.

Because the contaminated property is remediated rapidly, it is returned to a useful and marketable condition much sooner. The LCRS installation is permanent. It can be reactivated in the future to monitor the site as well to protect the site from the possibility of future spills. For this reason the LCRS can truly be regarded as an investment in the property that not only solves a current problem but enhances the value of the property for the future.

HTI's technology has been used in cleanup efforts on contaminated sites for dissolved and free phase hydrocarbon contamination extraction, for aquifer recharge with treated effluent or processed water, and for leachate containment and recovery. The system minimizes the physical handling of contaminated soils and materials as well as the exposure of personnel to contaminants. Systems have been installed on sites in the Midwest, East, Northeast, South and Southeastern United States.

Trenched Horizontal Wells provide unequaled performance in low hydraulic conductivity materials that cannot be remediated using conventional approaches. In many cases, low hydraulic conductivity sites that could not be economically remediated using conventional approaches have been restored in record time with significant cost savings.

Trenched Horizontal Wells have been employed successfully to exfiltrate a treated effluent back into the surficial aquifer in low hydraulic conductivity material. The benefits of using HTI's system for this purpose result from cutting a narrow trench down through the naturally occurring strata and backfilling it with a high hydraulic conductivity material creating a vertical preferential flow path. By cutting through layers of lower hydraulic conductivity material, the restriction is overcome allowing water to be exfiltrated back into the formation without having to cross layers of lower hydraulic conductivity. This enables the trench to maximize the exfiltration volume while minimizing the mounding of the ground water table which limits the rate at which water can be exfiltrated. Typically, the delivery pipe is placed above the water table so that injection well permitting does not become an issue.

Trenched Horizontal Wells can be used for a number of purposes, such as:

- Ground water withdrawal
- Air sparging
- Soil flushing in-situ
- Bio-venting
- Bioremediation in-situ
- Soil Vapor Extraction
- Exfiltration of effluent
- Leachate containment/collection
- Free product recovery
- Treatment Walls

POLYWALL Barrier System Treatment Walls (The 21st Century Containment System)

This innovative subsurface environmental control technology, the POLYWALL Barrier System, was developed by Horizontal Technologies, Inc. and offers a number of unique features over other types of cutoff and containment walls. For years slurry walls constructed of bentonite clay mixed with native soils have been used for containment purposes with varying degrees of success. The POLYWALL Barrier System succeeds where slurry walls have failed.

The POLYWALL Barrier System consists of equipment and materials that place a continuous sheet of 40 to 100 mil High Density Polyethylene (HDPE) geomembrane vertically to depths of more than 30 feet. The HDPE geomembrane is manufactured using virgin, first quality, high molecular weight polyethylene specifically formulated to be most resistant to sunlight, chemicals, leachate, toxic wastes and hydrocarbons. HTI can provide a high performance, hydrophilic interlocking waterproof joint system that provides exceptional strength and can be visually inspected as it is being made. These joints are not only impervious to fluids at initial installation but remain fluid tight for the life of the barrier.

Virtually any length or configuration of POLYWALL can be installed without concern over possible holes or windows inherent in other subsurface cutoff-containment structures. This system can be combined with HTI's Linear Contaminant Remediation System (LCRS) and a wide variety of other in-situ and above grade remediation systems. Other potential uses include prevention of leakage through levees, isolation of wetlands and sensitive areas, control of ground water flow, and a wide variety of civil and hydraulic engineering applications.

In October 1993, HTI completed its first project involving the installation of POLYWALL for the State of New York. The proprietary POLYWALL Barrier System was successfully employed to cut off the migration of a free product phase diesel fuel plume into the Little River in Star Lake, New York. The system was installed continuously along the river bank a distance of 1,350 lineal feet. Once the site was prepared, the actual installation of the POLYWALL Barrier System was completed on budget and ahead of schedule.

At the heart of the POLYWALL installation at Star Lake was a 40 mil high density polyethylene (HDPE) membrane. The POLYWALL extended vertically from above land surface to depths of 10 to 15 feet. The POLYWALL Barrier System is being used at the site in conjunction with a Trenched Horizontal Well. The Horizontal Well is being used to recover the free product that is now trapped on the upgradient side of the POLYWALL.

Barrier walls have a number of applications in the fields of water supply and conservation as well as in remediation of soils and ground water contamination. One of its many benefits is the potential for utilization under emergency conditions where rapid installation is critical.

Advantages include:

- lower cost than conventional techniques such as slurry walls
- rapid installation process
- can accommodate irregular geometry/topographies
- installed in 14-inch wide trench resulting in minimal generation of trenching spoils
- offers positive control of subsurface environments through isolation, containment and/or separation
- compatible with HTI's Linear Contaminant Remediation System (LCRS) for ground water capture and control and contaminant removal
- can be used with in-situ treatment technologies such as physical, chemical and biological reactors
- eliminates subsurface installation dewatering and resultant disposal requirements
- joints can be visually inspected as they are made
- can be installed in high hydraulic conductivity material

Water Supply

The major sources of irrigation waters have traditionally been vertical wells in deeper aquifers and surface water impoundments such as ponds and lakes. As demands on these sources continue to grow for potable water and for water for industrial use, problems have also grown. Salt water intrusion in coastal areas, draw down of lake levels and general deterioration of water quality have increasingly limited the use of these sources for agricultural purposes. The current regulatory approach is to limit and restrict consumptive use in order to protect the available deep aquifer resources.

HTI's system provides a unique means to utilize shallow surficial aquifers as a water source for municipal, industrial and agricultural purposes. The placement of a Horizontal Well screen in the surficial aquifer, plus the effects of the trenching creating a preferential flow path through impermeable layers, creates a highly efficient means of recovering shallow ground water. This ground water source is not only recharged by rain, but also by a significant percentage of irrigation water as well as by percolation and side bank leaching.

HTI's system offers the opportunity to recover and reuse water from the surficial aquifer for the following purposes:

- primary and secondary sources for public water supply
- primary irrigation for citrus, row and truck crops
- primary source irrigation for golf courses
- irrigation and freeze protection for ferneries
- control of lake water levels in conjunction with POLYWALL Barrier System
- wetland preservation and mitigation in conjunction with POLYWALL Barrier System
- primary and secondary sources for fire protection
- aquifer recharge
- tail water recovery

The Florida Department of Environmental Protection, in conjunction with Volusia County, Florida, Soil and Water Conservation District, St. John's River Water Management District and the University of Florida, Institute of Food and Agricultural Services are conducting a Horizontal Well Demonstration Program. The project objective is to demonstrate the effectiveness of Horizontal Wells at intercepting and recycling leached nitrates before they enter the surficial aquifer. In addition, the project will demonstrate the effectiveness of Horizontal Wells in supplying irrigation and freeze protection water from surficial aquifers in order to reduce the volume of water pumped from the Floridan aquifer. The funding for this demonstration is Section 319, Grant Funds from U.S. E.P.A. through the F.D.E.P. The specifications for the Horizontal Wells are from the United States Department of Agriculture, Soil Conservation Service, approved Technical Guide, Field Office, Code 642, Section IV-A Cropland, Supplement to the Well Section.

List of Patents

October 3, 1989	Trenching Tool for Installing Perforated Pipe	4,871,281
May 22, 1990	Horizontal Dewatering System	4,927,292
November 20, 1990	Waste Water Drainage and Recovery System	4,971,690
August 21, 1991	Corrugated Drainage Tube	4,950,103
October 22, 1991	Continuations in Part of the Horizontal Dewatering System	5,059,064
	System for Lake Level Control	
	System for Agricultural Recovery & Reuse	
	System for Impervious Materials	
	System for Remote Fire Protection	
	System for Domestic Water Recovery & Reuse	
	Commercial System to Recycle Site Runoff from from Initial Rainfall	
December 17, 1991	Coupling Device	5,072,972
June 2, 1992	Leachate Containment System	5,118,230
October 12, 1993	Linear Contaminant Remediation System	5,252,226

LINEAR CONTAMINANT REMEDIATION SYSTEM (LCRS)

Client, Location, Engineer

- Bechtel-Monsanto, New Jersey, Bechtel
- Oil Company, Winter Haven, FL, Delta Environmental
- Lee County, Lee County, FL, Missimer
- Dana Corporation, Richmond, IN, R.M.T.
- Conserve Inc., Mulberry, FL, Ardaman & Assoc.
- St. Joe Paper Co., Panama City Beach, FL, Alvarez Lehman
- Schwegman Giant Stores, Inc. New Orleans, LA, P.S.I.
- State of Florida, Pahokee, FL, Rust Environmental
- State of Florida, St. Augustine, FL, ICF Kaiser
- State of Florida, Miami, FL, Groundwater Technology
- Publix, Pinellas Co., FL, Chastain Skillman
- Dade Co. D.E.R.M., Miami, FL, Metcalf & Eddy
- Alcoa, Massena, NY, CDM/MK
- Home Depot, St. Petersburg, FL, Williams Company
- CSX Transportation, Boca Grande, FL, Environmental Science & Engineering
- U.S. E.P.A., Sarasota, FL, R. F. Weston
- Fairbanks Superfund Site, Gainesville, FL, Westinghouse Remediation
- Reynolds Aluminum, Massena, NY, Bechtel
- Langley Air Force Base, Langley, VA, C.O.E./Law Engineering
- Miami International Airport, Miami, FL, OHM Remediation Services
- Andrews Air Force Base, Prince St. Georges County, MD, Dames & Moore
- U. S. Air Force, Port Canaveral, FL, O'Brien & Gere
- U.S. Coast Guard, Elizabeth City, NC, Parsons Engineering
- Texaco Refining, Casper, WY, TRC Environmental

POLYWALL BARRIER SYSTEM

Client:	New York State Department of Environmental Conservation
Project:	J & L Steel Co.
Location:	Star Lake, NY
Client:	FDOT
Project:	Chevron
Location:	Jacksonville, FL
Client:	Tosco Corporation
Project:	Duncan Refinery
Location:	Duncan, OK
Client	Citgo Asphalt Refinery
Project	Savannah Refinery
Location:	Savannah, GA

WATER SUPPLY

Owner, Location

- Ft. Lauderdale International Airport, Ft. Lauderdale, FL
- Bonita Bay Golf Club, Bonita Springs, FL
- Spanish Wells Country Club, Ltd., Bonita Springs, FL
- LaCita Country Club, Titusville, FL
- University of Florida, Institute of Food & Agricultural Sciences (IFAS) Citrus Research & Education Center, Ft. Pierce, FL
- McDonnell Douglas, Melbourne, FL
- Collenton River Plantation, Hilton Head, SC
- Bonita Fairways Golf Club, Bonita Springs, FL
- Charles Edwards Groves, Punta Gorda, FL
- Bob Paul Citrus, Felda, FL
- West Groves, Ft. Pierce, FL
- Red Smith Ferneries, Pierson, FL
- The Breakers, Palm Beach, FL

Representative Horizontal Technologies Projects

HTI has installed its trenched horizontal well system (L.C.R.S.) in more than 80 sites with contaminated soil or ground water in Midwestern, Northeastern and Southeastern U.S. HTI originally developed the L.C.R.S. to improve cleanup of dissolved and free phase hydrocarbon contamination, aquifer recharge with treated effluent or processed water, and leachate containment and recovery.

The following are examples of HTI's applications of trenched horizontal recovery systems in remediation work:

Langley AFB, Virginia

This HTI job is related to work for the Defense Department's Installation Restoration Program and involves installation of 19 horizontal recovery wells to capture a shallow free product and dissolved-phase jet fuel plume covering 30 to 40 acres, primarily under the base's concrete taxiways. The base is underlain by unconsolidated, low-hydraulic conductivity sands and silts. Most of the recovery wells had to be installed beneath the base's concrete taxiways. HTI installed 3,300 feet of horizontal wells approximately 18 feet below land surface. High-hydraulic conductivity sand pack was also installed. All wells were pumped after installation to ensure that design flow rates had been achieved. Conventional separation and air stripping was used to treat water recovered from the surficial aquifer.

Tamarac, Florida

This 1991 project was HTI's first commercial use of its Linear Contaminant Remediation System (L.C.R.S.) to recover contaminated ground water. Use of the horizontal wells cut cleanup time by more than 80 percent. Cleanup via 41 vertical wells of BTEX-contaminated underground water supplies at this Broward County abandoned municipal fuel storage facility was estimated at 30 months. Actual cleanup using eight horizontal recovery wells to remediate the site took just eight weeks. Using cycled soil flushing and pump and treat techniques, 1.73 million gallons of recovered ground water were pumped through an activated carbon filter and returned to the site by spreading.

The recovery wells were 12.5 feet deep, 12.5 feet apart, and averaged 55 feet in length, with a flow rate of 150 gallons per minute. Treatment duration was 60 days. Performance data before and after treatment is shown below in milligrams/liter (mg/L): ◦ Benzene, 1,600 mg/L before treatment and <0.005 mg/L after treatment; ◦ Toluene, 450 mg/L before treatment and <1 mg/L after treatment; ◦ Ethylbenzene, 1,400 mg/L before treatment and <0.7 mg/L after treatment; ◦ Total Xylenes, 4,000 mg/L before treatment and <10 mg/L after treatment.

Law Enforcement Center, Charlotte, North Carolina

Initial treatment for the Law Enforcement Center ground water contaminated by 300,000 gallons of hydrocarbons called for 100 vertical wells at a cost of $1 million. HTI's installation cost was $300,000 to $350,000. Costs including the SVE system and ancillary pipe and controls were approximately $575,000.

HTI installed seven horizontal recovery wells to contain and capture both the free product and dissolved-phase BTEX plume and provide soil vapor extraction. The wells were installed in 1992 and went into operation in May, 1993.

Horizontal recovery wells were chosen for the site because they could obtain significant yields from low-hydraulic conductivity material, because they allowed for installation of a vapor extraction line at the top of the drain trench and bed and because HTI could install horizontal wells with a precision that can be difficult to obtain with directional drilling techniques. The site geology consisted of unconsolidated silty sand and clay interbedded with weathered rock fragments 12 to 25 feet below land surface across the site. The site was underlain by a dense granitic unit that acted as a confining unit. Slug test data indicated that hydraulic conductivity of the unconsolidated surficial material ranged from 0.022 to 81 feet/day. The contaminant plume was primarily beneath the facility parking lot. All seven recovery wells were either within or around the parking lot periphery. Because the surficial unit thickness varies significantly across the site, the well depth varied from 18 to 32 feet.

HTI used its trenching technology to install the vertical headers and horizontal wells at depths of 18 to 32 feet. Installation involved cutting and removing asphalt. The installation site was benched down over an area 14 feet wide and up to five feet deep. In some areas, rock and debris (land fill material) necessitated pretrenching. Approximately 400 L.F. of screen was placed eight feet into fractured saphrolite to recover free-phase product.

After the recovery wells were installed, SVE system piping was installed in the upper portion of the trench. The bench was backfilled, and the asphalt over the trenches was replaced. Each well was pump developed to ensure that the design flow rate would be achieved. The well diameter was six inches, total length was approximately 1,200 feet, and individual lengths varied from approximately 100 to 360 feet.

Miami International Airport - Concourse C - Miami, Florida

Horizontal Technologies, Inc. (HTI) installed five trenched horizontal wells at a depth of 12 feet below land surface. The wells were used primarily for combined free product extraction and dissolved phase jet fuel contamination. All of the wells were installed with a high hydraulic conductivity sand pack from six inches below the well screen to the top of the saturated portion of the Miami Oolite.

In all, approximately 730 feet of six-inch diameter well screen was installed and sand packed. The wells were installed after a three foot section of the concourse's concrete was removed. The installation machine started after the precut sections of concrete were removed, and upon completion of the wells, the concrete was restored.

Sand-packed, trenched horizontal wells were chosen for this project because of their ability to obtain significant yields from relatively thin contaminated sections of the low hydraulic conductivity water table aquifer present at the site. It was also chosen because HTI's proprietary installation process provides the most cost effective means of installing the shallow, high-efficiency horizontal well system.

Naval Amphibious Base Little Creek - Norfolk, Virginia

HTI installed a Polywall Barrier Wall for NAB Little Creek located in Norfolk, Virginia. The installation was accomplished in a single pass to install five separate continuous 22-foot vertical sheets of HDPE. The base of the sheet was installed at a depth of approximately 16 feet below grade in five segments adjacent to Piers 11 through 19 on the waterfront. The HDPE that was used was a thickness of 60 mil.

HTI installed the impermeable membrane approximately 7 to 8 feet landward of a waterfront bulkhead. The Polywall installation began with cutting and removal of the concrete pavement for each of the five sites; a total width of four feet centered along the proposed location of the barrier wall.

In all, approximately 450 feet of Polywall was installed for the U.S. Navy for the containment of LNAPL fuel oil contamination which had previously been discharging to tidal waters. The project was successfully completed in a minimum amount of time without causing a significant disruption of the pier-front activities. HTI was the selected vendor because it was deemed the only acceptable, technically feasible alternative that provided assurance of a leak-proof non-reactive barrier and the cost-effectiveness of the product. As a result of the success of this project, HTI is now negotiating the installation of another barrier wall project with the Navy on a sole-source basis.

State of New York D.E.C. - Star Lake, NY

Horizontal Technologies, Inc. (HTI) proprietary Polywall Barrier System was successfully installed to cut off the migration of diesel fuel into the Little River in Star Lake, New York. The Polywall is being used in conjunction with a Linear Contaminant Remediation System to recover free product and control groundwater flow. The system was installed continuously along the river bank for a distance of 1,350 lineal feet to depths of 15 feet below ground surface with water table/free product interface at an average depth of four feet.

United States Coast Guard Station, Elizabeth City, North Carolina

HTI installed the first iron filing treatment wall using a one-step trenching process. The use of HTI's trenching and delivery system technology enabled never-before achieved cost effectiveness for permeable treatment wall installations. This project involved the installation of 200 linear feet of iron filing treatment wall to remediate a TCE and chromium plume from an adjacent aircraft manufacturing facility. The site is located at the United State Coast Guard Station in Elizabeth City, North Carolina. The plume was migrating off the base into the tidal surface water body known as Albermarle Sound.

The installation involved retrofitting our largest trencher (#6009) to cut a nominal 28-inch wide trench to 25 feet below land surface using a dual cutter chain configuration. The trencher was outfitted with a 24-inch wide feed box in order to place the iron filings to a depth of 25 feet below land surface.

The permeable treatment wall was installed down gradient from the source, across the plume, parallel to the Albermarle Sound shoreline. As the installation progressed, excavated soil was conveyed to a stockpile and replaced with the zero-valent iron filings.

The installation will be the site of continued study by the EPA's Kerr Laboratory in Ada, Oklahoma, to determine the removal effectiveness and useful life of the treatment wall. A small scale pilot test was completed at the site with positive results subsequent to this installation.

FDOT Fairbanks Pit

HTI working in conjunction with Westinghouse Remediation Services is just wrapping up the installation of 4,200 feet of the deepest trenched horizontal wells ever installed in the Americas and possibly the world. For the project HTI designed and built an installation machine that is capable of installing 5"-6" interior diameter HDPE well screen at a depth of 32 feet below the base of the installation machine. Depths of 50 feet BGS were achieved by benching.

The critical portion of this project was the ability to install the sand packed wells in the low hydraulic conductivity surficial silty sands without having to dewater the runs or excavate contaminated surficial material. The project is a RCRA site and the approved plans required that the wells be placed at the base of the surficial. HTI constructed the 32 foot machine to avoid having to excavate significant quantities of material from below the water table. As a result of the topographic relief over the site, some of the wells were benched down into the vadose zone as much as 20 feet. These deep benches allowed the installation of the wells at the base of the surficial aquifer unit in these areas.

All of the fourteen wells were sand packed with a high hydraulic conductivity sand from approximately 6 inches below the invert of the well screen up to the water table. Eight inch diameter vertical risers were used on the pumping end of the wells.

Citgo Asphalt Refinery - Savannah, GA

Horizontal Technologies recently completed the installation of its proprietary Polywall Barrier System at the Citgo Asphalt Refinery in Savannah, GA. The plant is located on the Savannah River, and its site has been used by industry since the early part of the century and during World War II served as a dry dock facility for the Navy. The site had become suspect of discharging LNAPL's into the Savannah River at intervals and had received the attention of the Coast Guard and other agencies concerned with the cleanup of the nations' waterways. DNAPL's were also present and posed part of the problem. The site was under lain by silty sands down to 15' with a clay layer beginning at this depth and extending to forty feet or more. Citgo chose Polywall for this project over other technologies because this system provided the most economical answer to this problem while offering as side benefits the best and quickest cutoff options. The wall was placed at a depth of twenty feet BGS and extended some eleven hundred feet along the river interface with two 100' returns on each end, providing fifteen hundred feet of continuous coverage. Interlocking self-sealing joints were placed at 180 foot intervals allowing construction of the continuous wall with only seven joints. Scheduling was critical because of other construction taking place that could not be interrupted. The site had an inordinate amount of below-ground utilities that had to be worked around, and extensive exploration of the Polywall path and preparation of the site prior to construction provided an in-place wall with only thrirteen days of actual construction time. Even though the water table was fluctuating and at high tide was only three feet below ground surface, the installation was made without dewatering. Special construction techniques also minimized the amount of contaminated material that had to be handled. The wall was constructed of forty mil high-density polyethylene manufactured by National Seal. The fast track project took less than thirty days from contract signing to job completion, and was finished ahead of schedule and within contract price.

Texaco Refinery Marketing - Casper Refinery
Casper, Wyoming

The construction period for this project was from July, 1996 to December, 1996. HTI subcontracted to Texaco Refinery Marketing to construct an innovative groundwater Light Non-Aqueous Phase Liquid (LNAPL) and Dense Non-Aqueous Phase Liquid (DNAPL) collection system (Trenches 1 and 2) integrated with a downgradient Polywall barrier. The Polywall Barrier System extended from depths of 22 feet below land surface to approximately 26 feet below land surface for a total of 1,550 feet. The lithology consisted of flowing sand combined with cobbles and boulders. The installation was accomplished adjacent to the North Platte River. The collection system components were installed upgradient to the Polywall. A groundwater collection system was installed at depths of approximately 18 feet immediately adjacent to the Polywall. The upper portion of the groundwater collection trench was equipped with LNAPL collection sumps. The groundwater and LNAPL collection systems extended the entire length of the 1,550 foot Polywall Barrier System.

In addition to the LNAPL and groundwater collection system, a DNAPL collection system was installed approximately one foot into the bed rock for a 320 foot section of the project. The DNAPL collection trench extended to depths of approximately 31 feet to 15 feet below land surface.

Due to the superior recovery capabilities demonstrated from the installation of trenches 1 and 2, HTI was subsequently contracted to install a replacement trench for a recently installed conventional trench utilizing our proprietary technology. The trench was installed to replace an ineffectual collection system that was unable to meet regulatory criteria. HTI installed the additional trench (3A) approximately two feet into the bed rock and equipped trench 3A with a central sump to provide complete dewatering to the top of the bed rock.

This was an extremely difficult project because in addition to having to operate in flowing sands, there were numerous cobbles and boulders that had to be trenched while maintaining the integrity of the installation.

For Further Information, Call 941-283-5640 or 941-283-2222 (Fax) or E-mail to info@horizontal.com

2

What is a Trenched Horizontal Well?

Water Supply

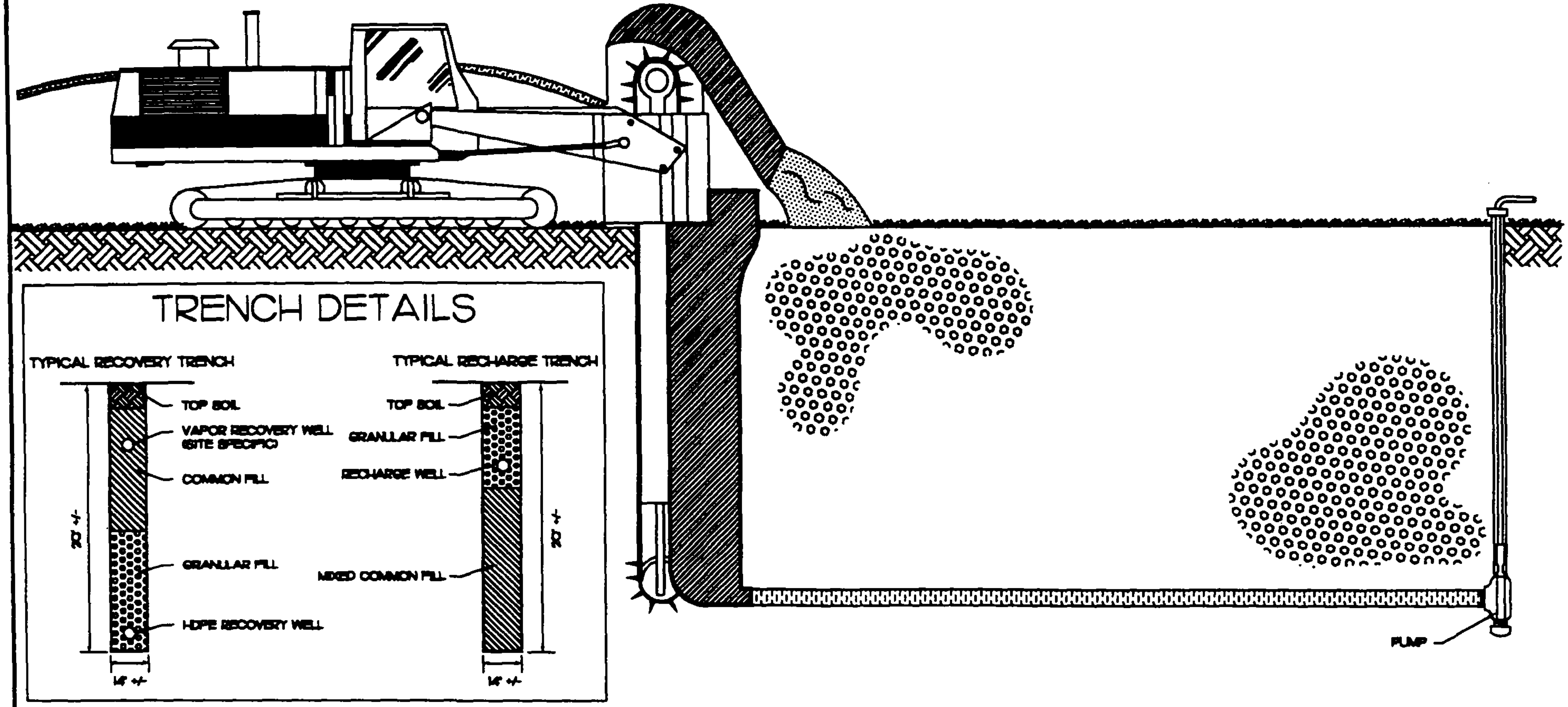
The major sources of irrigation waters have traditionally been vertical wells in deeper aquifers and surface water impoundments such as ponds and lakes. As demands on these sources continue to grow for potable water and for water for industrial use, problems have also grown. Salt water intrusion in coastal areas, draw down of lake levels and general deterioration of water quality have increasingly limited the use of these sources for agricultural purposes. The current regulatory approach is to limit and restrict consumptive use in order to protect the available deep aquifer resources.

HTI's system provides a unique means to utilize shallow surficial aquifers as a water source for municipal, industrial and agricultural purposes. The placement of a Horizontal Well screen in the surficial aquifer, plus the effects of the trenching creating a preferential flow path through impermeable layers, creates a highly efficient means of recovering shallow ground water. This ground water source is not only recharged by rain, but also by a significant percentage of irrigation water as well as by percolation and side bank leaching.

HTI's system offers the opportunity to recover and <u>reuse</u> water from the surficial aquifer for the following purposes:

- primary and secondary sources for public water supply
- primary irrigation for citrus, row and truck crops
- primary source irrigation for golf courses
- irrigation and freeze protection for ferneries
- control of lake water levels in conjunction with POLYWALL Barrier System
- wetland preservation and mitigation in conjunction with POLYWALL Barrier System
- primary and secondary sources for fire protection
- aquifer recharge
- tail water recovery

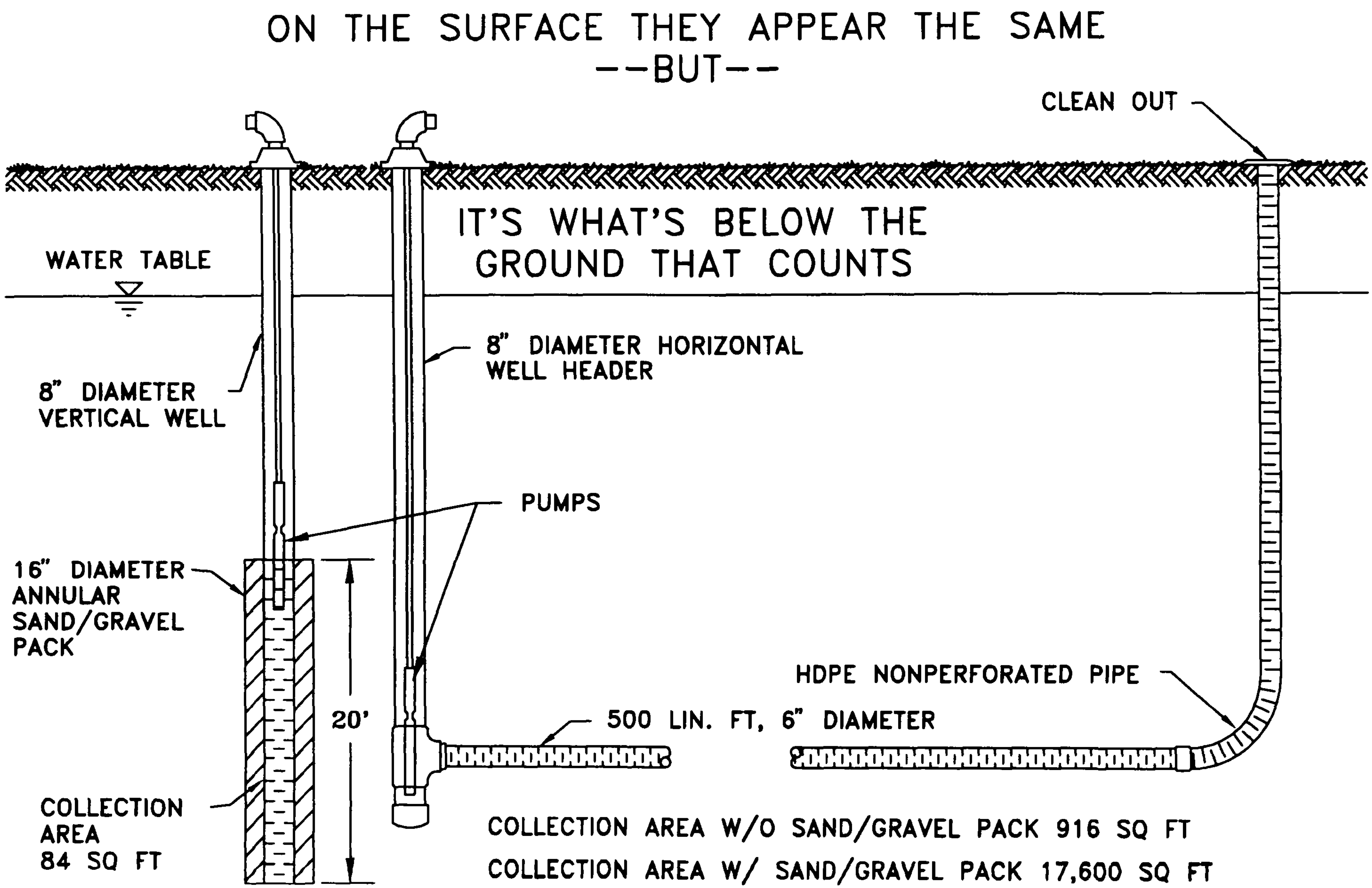
The Florida Department of Environmental Protection, in conjunction with Volusia County, Florida, Soil and Water Conservation District, St. John's River Water Management District and the University of Florida, Institute of Food and Agricultural Services are conducting a Horizontal Well Demonstration Program. The project objective is to demonstrate the effectiveness of Horizontal Wells at intercepting and recycling leached nitrates before they enter the surficial aquifer. In addition, the project will demonstrate the effectiveness of Horizontal Wells in supplying irrigation and freeze protection water from surficial aquifers in order to reduce the volume of water pumped from the Floridan aquifer. The funding for this demonstration is Section 319, Grant Funds from U.S. E.P.A. through the F.D.E.P. The specifications for the Horizontal Wells are from the United States Department of Agriculture, Soil Conservation Service, approved Technical Guide, Field Office, Code 642, Section IV-A Cropland, Supplement to the Well Section.



HTI	Horizontal Technologies, Inc. P.O. Box 150820 Cape Coral, FL 33915	PROJECT:
		TITLE: Trencher & Trench Details
		DRAWN BY: BGG · DATE: 1/25/94 · PLATE: TOL2

Applications for Trenched Horizontal Wells

- ▲ Water Supply
- ▲ Contamination Remediation
- ▲ Exfiltration Galleries
- ▲ Groundwater Control
- ▲ Thermal Exchange

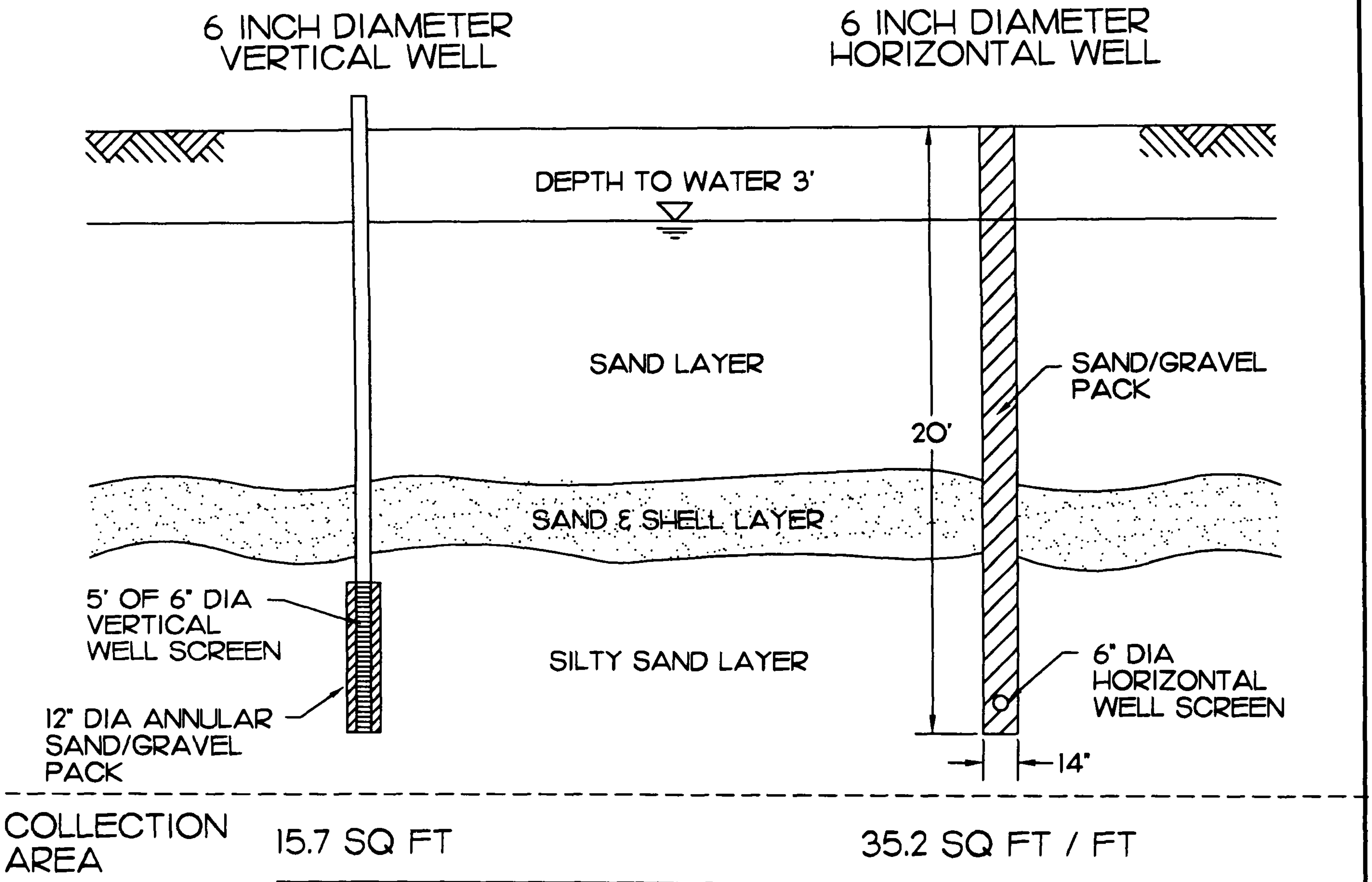


Horizontal Technologies, Inc.
P.O. Box 150820
Cape Coral, FL 33915

PROJECT:

TITLE: Vertical/Horizontal Well Comparison

DRAWN BY: BGG | DATE: 1/23/94 | PLATE: REM10

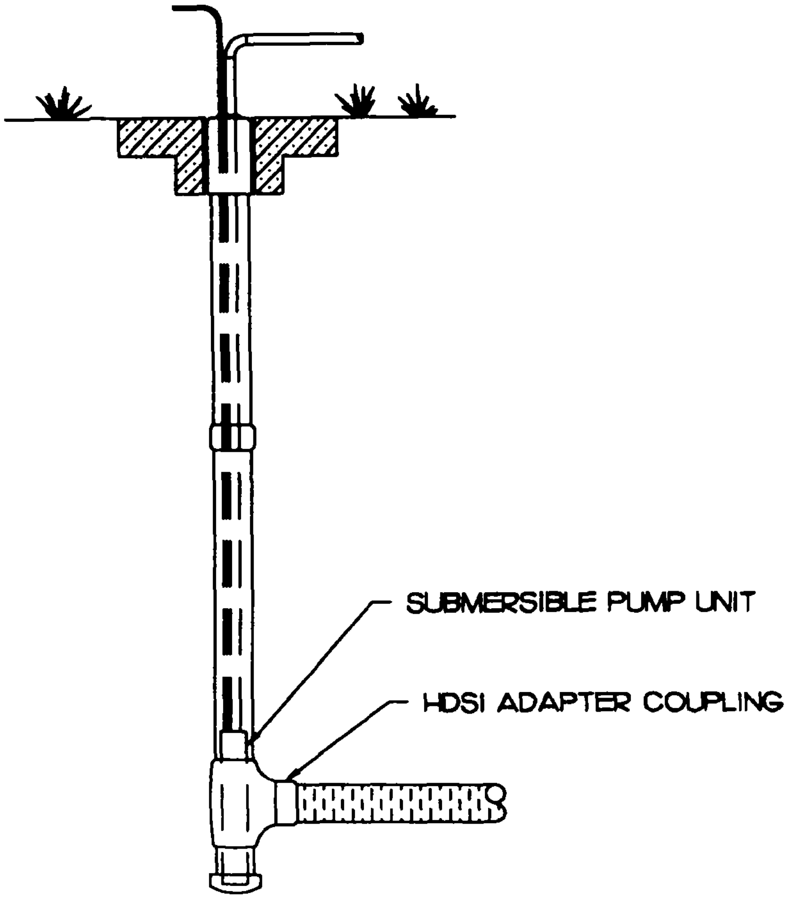


Horizontal Technologies, Inc.
P.O. Box 150820
Cape Coral, FL 33915

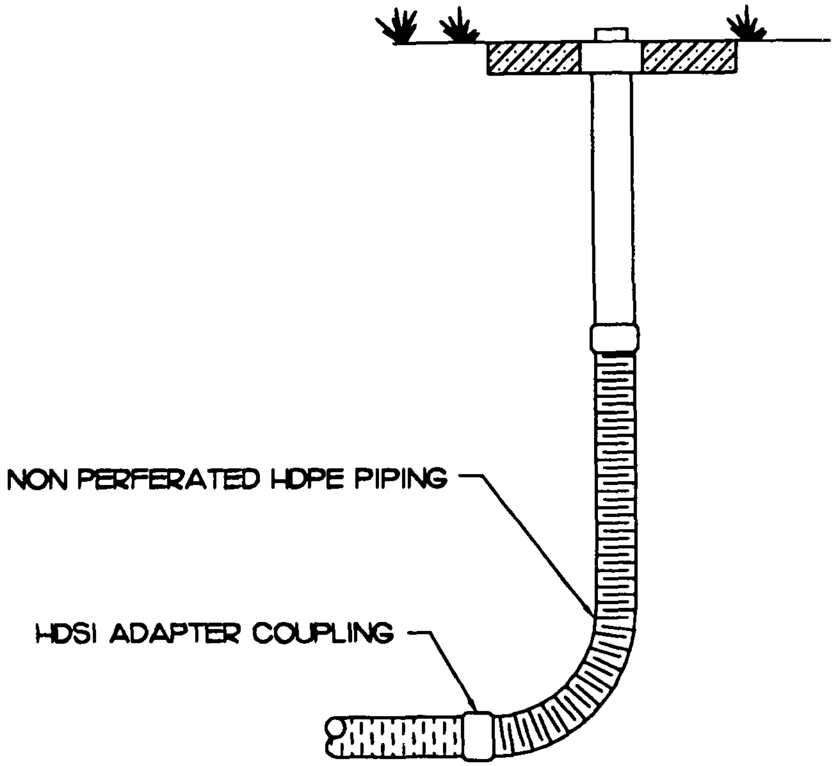
PROJECT:

TITLE: Vertical/Horizontal Well Comparison

DRAWN BY:	DATE:	PLATE:
BGG	1/23/94	REM9



END PUMPING RISER
8"-10" DIAMETER



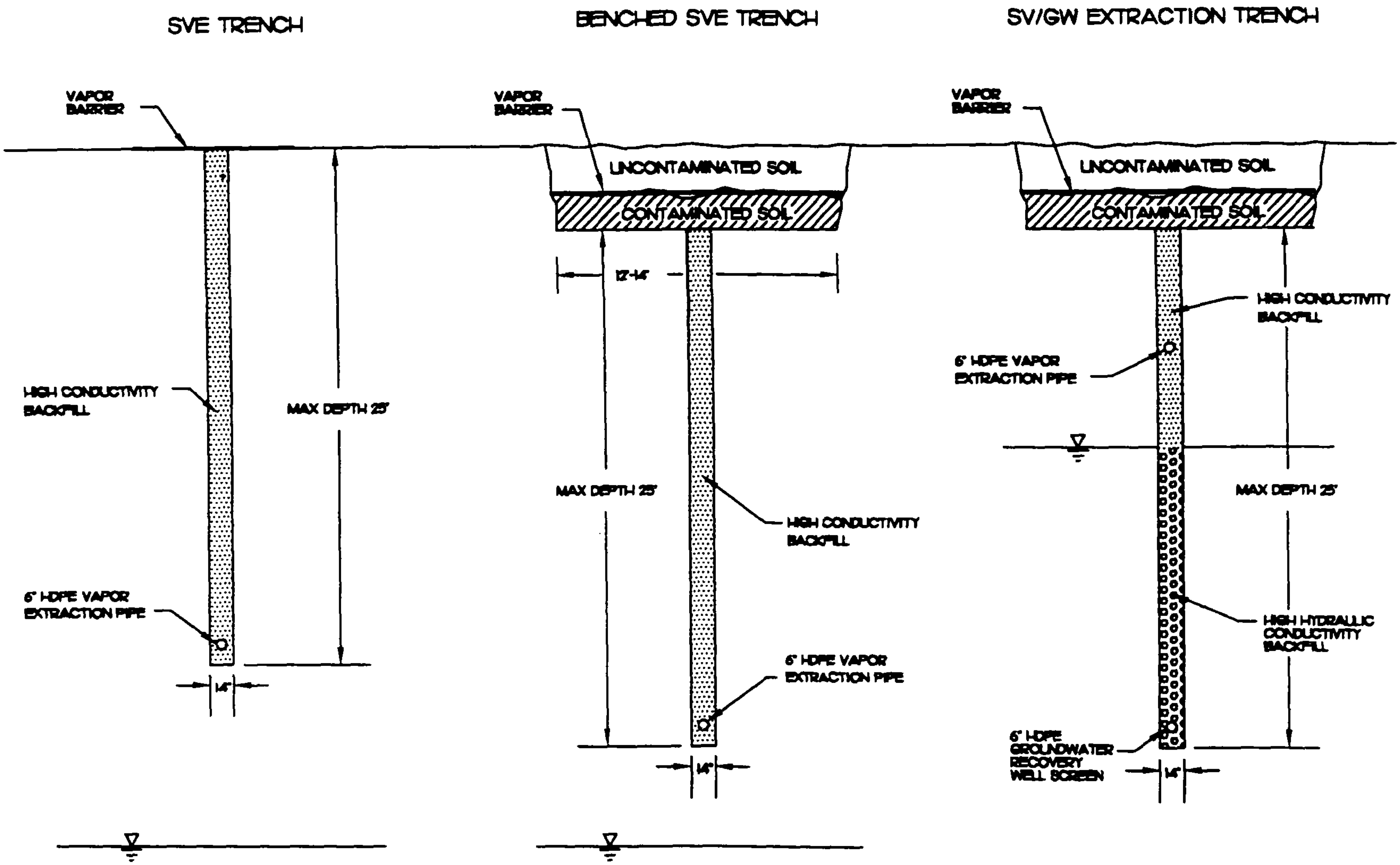
CLEAN OUT END

Horizontal Technologies, Inc.
P.O. Box 150820
Cape Coral, FL 33915

PROJECT:

TITLE: Riser & Cleanout Details

DRAWN BY:	DATE:	PLATE:
BGG	1/30/94	REM18



Horizontal Technologies, Inc.
P.O. Box 150820
Cape Coral, FL 33915

PROJECT:	
TITLE:	Bench Details

DRAWN BY:	DATE:	PLATE:
BGG	1/21/94	BNH1

Horizontal wells - a new option for citrus irrigation

By Richard Frisbie

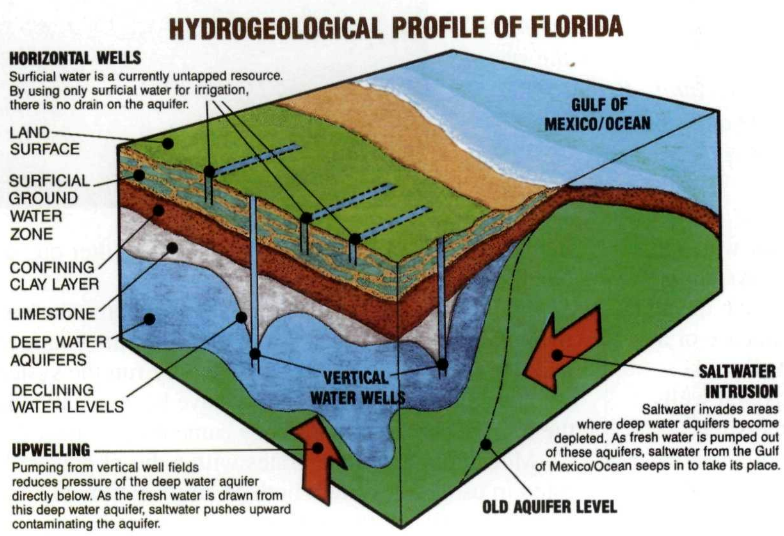
A unique groundwater recovery system for the irrigation of citrus groves recently has been introduced in Florida by Horizontal Technologies, Inc., a firm founded in 1987 at Cape Coral.

The horizontal well, as opposed to a vertical artesian well, is installed by special equipment to a depth of 16 to 25 feet, vertically, then a horizontal filter cloth recovery pipe is laid in a 14-inch wide trench with varying lengths of pipe from four hundred to six hundred lineal feet spans. A flexible header-riser on one end and a controlled pumping point on the other, with the appropriate controls, heads and fixtures, completes the system.

This concept has been utilized in other industries, such as golf course construction, where the horizontal well is used as both a primary and secondary irrigation source.

James R. Powell, senior vice president of Horizontal Technologies, Inc. says, "There are a number of advantages to the horizontal well. First, the capital cost of installation is significantly less than a conventional deep well, which may have to be drilled to a depth of 1500 feet. Then, with the horizontal well, 30 to 50 percent of the water used is immediately recovered in the same aquifer from which the water was originally drawn. The energy savings realized by pumping from a 20 foot depth is tremendous."

"Potable water and its sources are a major concern and serious problem in many areas throughout the country. Fort Pierce citrus groves, for instance, have both a water quality and quantity problem. A high level of chloride occurs in the water there. In the past, the water source tapped by horizontal wells has been basically ignored."



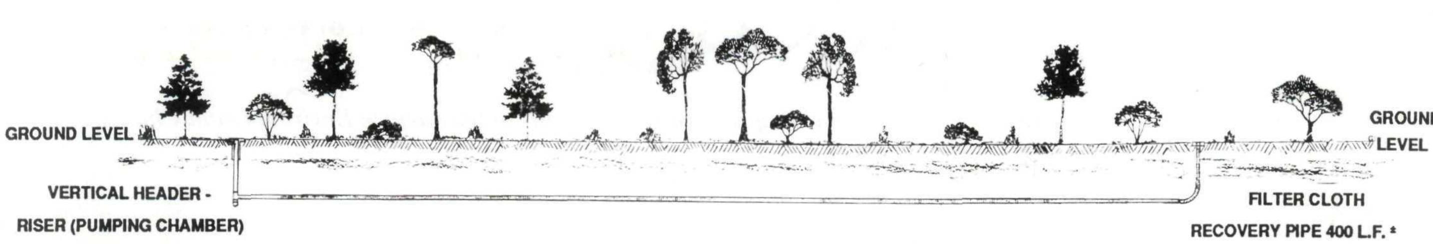
According to Powell, research personnel with IFAS stations at both Lake Alfred and Fort Pierce expressed an interest in this relatively new concept for use both as an irrigation water source and cold protection device. Horizontal Technologies, Inc. recently installed a system at the Fort Pierce IFAS station, and citrus growers were guests at a December demonstration of the system.

There are now horizontal wells being used in three citrus groves operations in the state. The first one was installed less than eight months ago at the Joe Noelke grove site in Fort Pierce. There, four wells are being used to serve 160 acres of citrus. The second system was installed by Fred Trippensee Co. in a forty acre grove at Sebring. The most recent installation was at the Darrell McCullough grove in Laredo. McCullough has an annual allocation of 3.54 million gallons.

When installing a horizontal well, the labor force required normally is a trencher operator and two men. Powell feels that as their marketing efforts gain momentum, and more growers learn of the system, 250 grove installations in 1991 is a possibility.

Installation may be accomplished in one day, with the trench dug, pipe laid, plus back-filling accomplished all in one operation, and with a minimum of surface scoring.

Powell indicated that Donald Justice, owner and president of Horizontal Technologies, Inc., has been working on the concept of horizontal wells for approximately four years and received a U.S. patent on this system on May 21, 1990. Prior to that time, Justice was in the construction business, working with utility companies throughout Florida and in other states.



our electric power shut off and we lost our entire fruit crop. Cost of installing the horizontal system was less than for an artesian well.

"Johnson Irrigation just put in a jet spray system for us in one 40 acres block, and it is working great. The water is so clear I doubt we even need a filter. The water looks like it would in your swimming pool. I don't see how that sock can filter our sand the way it does," said Noelke.

This horizontal well recently was installed in an IFAS grove at Fort Pierce. The top photo shows the system hooked up to a portable power unit. Below, IFAS personnel check the volume of flow and clarity of water being pumped through the system.

"What the grove owner wants to know about his irrigation system is, 'How much water will it give me and for what period of time in case of a freeze situation?'", Powell said.

Although many horizontal wells may utilize electric submersible pumps Horizontal Technologies, Inc. also manufactures a diesel fueled portable power unit for those who are not comfortable with the possibility of a power outage, which might shut down their system at a crucial time.

Powell acclaims maintenance of the system is minimal on the well casing and collector pipes, with the pumping unit subject to the same maintenance requirements as any other system.

Grove manager Joe Noelke, Jr., says of the system installed in his 160 acre grove, "We put in the system when we were in a drought mode. As soon as we had the horizontal well system in place, it started raining. Maybe we should put in another system. So far as the system is concerned, it is working pretty well for us. We're getting a flow of 400 gallons per minute. In two of the wells we installed brand new 15 horsepower submersibles. The reason we went to horizontal wells was that we were getting pretty salty in our water flow from conventional wells.

All of our pumps are electric, so we won't be using the system for freeze protection. In the last freeze

Fred Trippensee was unavailable for comment on his installation, but McCullough said of the system placed in his young 10 acre Sunburst grove, "It looks pretty good, although I have only run the system for about 10 hours so far.

"Our system could probably have been installed in three or four hours, but the trencher broke down. They came back to next day and completed the job."

McCullough, who operates with a diesel powered centrifugal pump, is interested in using his system both as an irrigation and cold protection system. He had a 72 hour test run done when the system was first installed. The average flow was 512 gallons per minute during the test. An additional four hour test was completed, pumping both ends of the horizontal run. This resulted in a flow of 805 gpm.

The system in McCullough's grove extends 608 lineal feet, with a six inch filter cloth recovery pipe, an eight inch PVC pumping header, and a six inch corrugated non-pumping rise on the opposite end. Pipe was installed at a mean depth of 18 feet and is designed to serve 2000 trees.

McCullough stated that he went with the horizontal well rather than a vertical well because, "The cost for the horizontal well was somewhat less, and the same amount of water was available in both systems. It made sense to me to go with the horizontal system."

Reprinted from Citrus Industry Magazine.

REPRINTED FROM *Florida Specifier*

Horizontal Wells Tap Surficial Zone's Water

By DAVE HODGES
Managing Editor

To put it one way, Don Justice may have given the irrigation well business a new direction in Florida—horizontal instead of vertical.

At a time when most deep aquifers are under increasing demand and new water use permits are getting scarce, Justice's Horizontal Technologies, Inc. in Cape Coral, FL is extracting water from a largely untapped source. The well system his company installs at golf courses, citrus groves and foliage farms relies on water in the surficial zone, and the wells go no further than 20-24 feet deep to tap that source.

"It's a big deal," said Justice, president and founder of HTI. "It's going to change the way a lot of people do things."

The company just installed a horizontal well system at a brand new golf course in Hilton Head Island, SC. Justice said the customer had sunk traditional vertical wells, but the rising salt content of that water made it unfit for irrigation. Course officials switched to potable water from the local system, but irrigation costs jumped to $300 a day, he added.

With the horizontal well, the pumps pull up about 100 gallons a minute from the surficial zone. The water's quality is fine and the irrigation cost is greatly reduced.

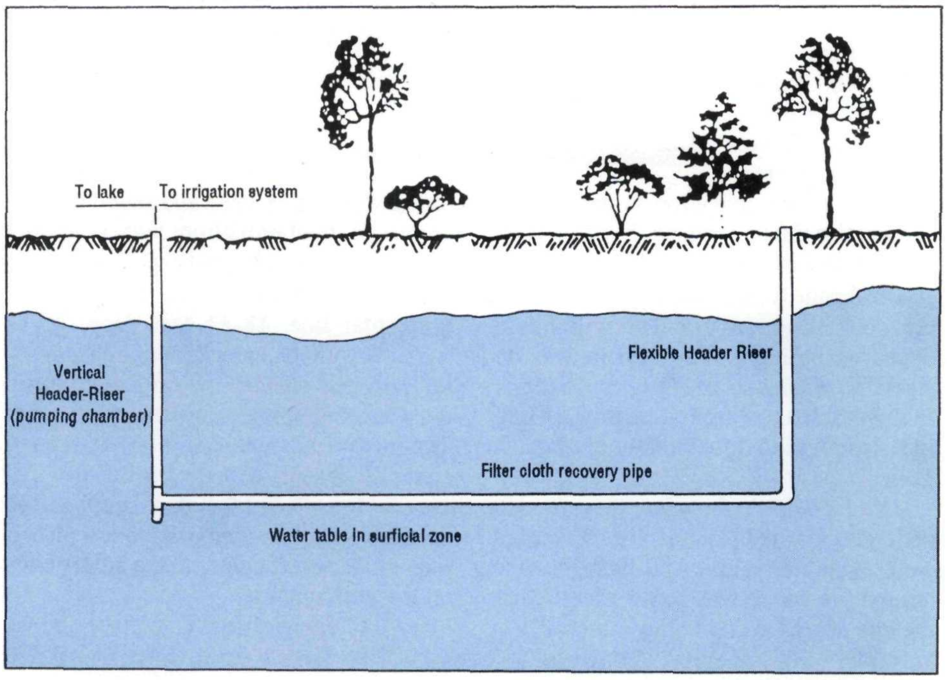
"We just developed a reliable way to tap into the water that before had been unattainable," he said.

A typical system consists of a 6-inch perforated recovery pipe inside a filter sock. Using a patented machine capable of digging a 14-inch-wide trench up to 24 feet deep, HTI excavates the trench, lays the recovery pipe and coves it up in one operation.

At one end of the horizontal pipe is a vertical riser with a pumping chamber that draws up the water to the surface. The other end has a flexible cleanout riser. The system is connected to a central control panel.

Philip L. Smith, owner of Hitching Post Farm in Pierson, has a horizontal well system to support his fernery operation. It consists of four horizontal sections of 800 feet each. Each is capable of producing 500 or more gallons per minute.

"This system has a potential output in excess of 2,000 gpm. Irrigation requirements are for not more than 1,500 gpm. The main feature of this system is its ability to reclaim most of the water it uses and that it uses surface water only," Smith wrote in a letter to the St. Johns River Water Management District describing his farm's water conservation plan.



Another agricultural test is under way in Fort Pierce at the University of Florida's Agricultural Research and Education Center. Justice installed a 6-inch recovery pipe 485 feet long, 17-18 feet below ground, in an AREC citrus grove. The vertical 8-inch pumping header contains a 20-horsepower stainless steel submersible pump. The setup yields a maximum of about 500 gpm.

Dr. David Calvert, the research center's director and soil chemist, said there has been a lot more rain this year, "so we are not using irrigation systems as much as we usually do." His colleague, agricultural engineer Dr. Brian Bowman, is measuring the drawdown characteristics of the well and the surficial water table's ability to withstand the pumping operation. Bowman has installed piezometers at different points around the well at varying distances and will plot those readings of underground water levels.

"It's a real nice supply of water. The water looks very desirable to me," Calvert said, adding it has been analyzed for salinity, mineral content, biochemical oxygen demand and other parameters. "More interesting to me is the quality of water from a salt content, the amount of chlorides, the amount of sodium." Indications are that it is better than the typical well water in groves along the Treasure Coast.

Calvert praised the concept that Justice has perfected. He added, however, that the surficial zone's hydrology is not the same at each locale. "Something you must keep in mind is that every soil and every substrata in Florida is different." Calvert recommends test borings first to gauge an area's supply potential.

North of the research center near the St. Lucie County Airport, the old county landfill is being converted to a municipal golf course. A horizontal well system there will be used to clear up an underground plume of contamination—and irrigate the course, said Pudge Guettler, whose company, Guettler & Sons Inc., is building the facility.

"There is a big potential for it," Guettler said of the horizontal configuration. Otherwise, an irrigation project must search for treated wastewater to use, or else stormwater that can be retained and used. Absent those options, a developer must seek a well permit. "No one likes you drilling (vertical) wells. All the agencies tell you that," Guettler said.

At the golf course, the horizontal pipes that crisscross the property draw down far more landfill leachate throughout the area than vertical wells would, Guettler said. He runs the water through an air stripper, then to the irrigation system, which sprays it on the golf course. Eventually, he noted, that water will percolate back to the surficial zone to be redrawn, and over time the contamination problem will be reduced accordingly. The system was designed by engineers of Hazen and Sawyer, PC, with assistance from Geraghty & Miller Inc. Installation took no more than 30 days.

"You couldn't do what they (county officials) needed to do with a vertical well," Guettler said. "And there's a dike around the whole site, so no water leaves the site and no water comes onto it."

> **"We just developed a reliable way to tap into the water that before had been unattainable."**
>
> **Don Justice, President**
> **Horizontal Technologies, Inc.**

There was a tradeoff—Guettler spent more to get water out of the ground, but got access to more water and the blessing of water management officials because the system isn't relying on the deeper aquifer.

Ed Alley, branch manager of Hazen and Sawyer's Fort Pierce office, said the golf course accounts for 150 acres of the 200-acre property. The county had been conducting groundwater tests through monitoring wells since 1985 and found that the plume of contamination was gradually moving toward the southeast.

The well installed totals 5,000 feet of horizontal line, 18-24 feet deep, in 12 sections with 12 independent pumps. Alley said that enables the operators to run most any pumping combination desired. The recovered water is routed through either of two air strippers, then flows in a gravity line to a lake that supplies the irrigation system. The main pond also is interconnected via pipes to the other ponds on the golf course.

"All of the hardware is in place and we are probably 95% complete with the pumps, and the electrical controls and the electrical power supply for the system," Alley said. Total output potential is 900,000 gpd.

"We're able to control the groundwater and treat it and reuse it through the golf course irrigation, so in effect we have a recycling of the water," he said. "This is a remedial action of a contaminated site, so one of the things they (permitting authorities) wanted us to do is limit our use of water, which we can do with the system."

On Florida's Gulf Coast, the horizontal well is a new approach and little is known right now as to whether it would work, said Kenneth A. Weber, PG, senior hydrologist in the Resource Regulation Department of the Southwest Florida Water Management District. For such wells to succeed, "you have to have a pretty good surficial aquifer," Weber added. "The question now is, where are those characteristics in our district?"

SWFWMD isn't granting well permits on the confined aquifers, Weber said, "so the surficial zone is the only place left where you can get water." The horizontal well needs more testing. "We think it has potential, but so far there's been no demonstration of it here."

3

L.C.R.S.

Linear Contaminant Remediation System

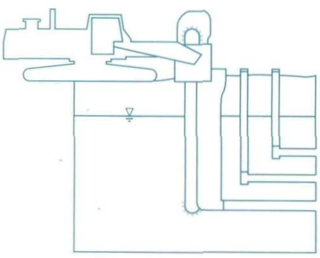
HORIZONTAL TECHNOLOGIES INCORPORATED

*Horizontal Technologies, Inc. (HTI) prepares to install a **Linear Contaminant Remediation System**. Shown is the vertical riser, the sand backfill chute, the Horizontal Well and the delivery mechanism.*

The Linear Contaminant Remediation System (LCRS) has been developed by Horizontal Technologies, Inc. to enable a timely, thorough, and cost-effective restoration of properties impacted by contaminated soil and groundwater.

The LCRS is comprised of single or multiple lines of multi-tiered trenched Horizontal Wells that offer a superior alternative to vertically or directionally drilled wells. Each system is designed to meet site-specific needs. The tiered wells in the LCRS can be used to inject or extract fluids, including air and water with or without the addition of chemical and/or biological compounds. This ability to alter the operational configuration of the entire LCRS results in complete in situ dialysis of both the saturated and unsaturated zones.

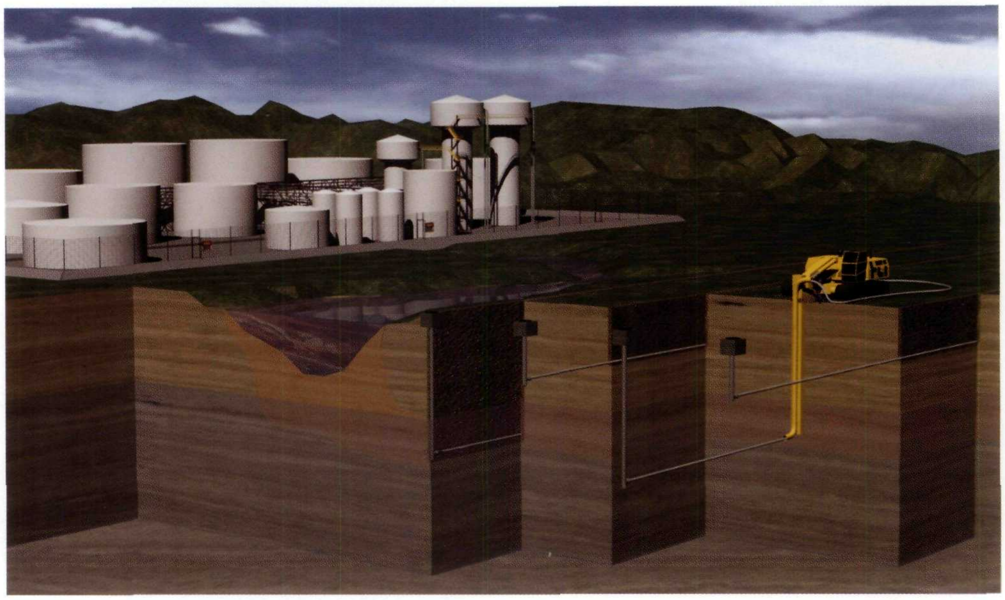
Installation of the LCRS is rapid, efficient, and accomplished using a specialized machine that cuts a nominal 14 to 16-inch wide (36 to 41 cm) trench, sets a vertical riser connected to the Horizontal Well and backfills the trench with either cuttings or a high-hydraulic conductivity backfill or media, typically sand or gravel. The equipment can also be configured to install multiple lines at different depths. All of this is done in a single pass without the need for an open trench or dewatering. This procedure greatly reduces the generation of contaminated soil, groundwater handling requirements and personnel exposure to contamination.



L.C.R.S.

U.S. PATENT
No. 5,118,230

The LCRS is proprietary technology and the system, process, and specific equipment components are protected under seven U.S. Patents.



Case histories of actual soil and groundwater remediation have demonstrated that use of the LCRS results in significant benefits which include:

- greater and more focused contact area with subsurface materials
- interception of preferential flow paths in heterogeneous soils
- exceptional performance in low-permeability soils
- reduced remediation time due to more efficient injection/extraction of fluids within the contaminated medium
- reduced operation, maintenance, and monitoring costs

The LCRS installation is permanent and the components are extremely durable, even in hostile environments. LCRS can be reactivated anytime in the future for monitoring at the site, or to provide the means of quickly remediating any new spill. The result is the rapid return of the contaminated property to a useful and marketable condition.

The LCRS can be used for multiple purposes such as:

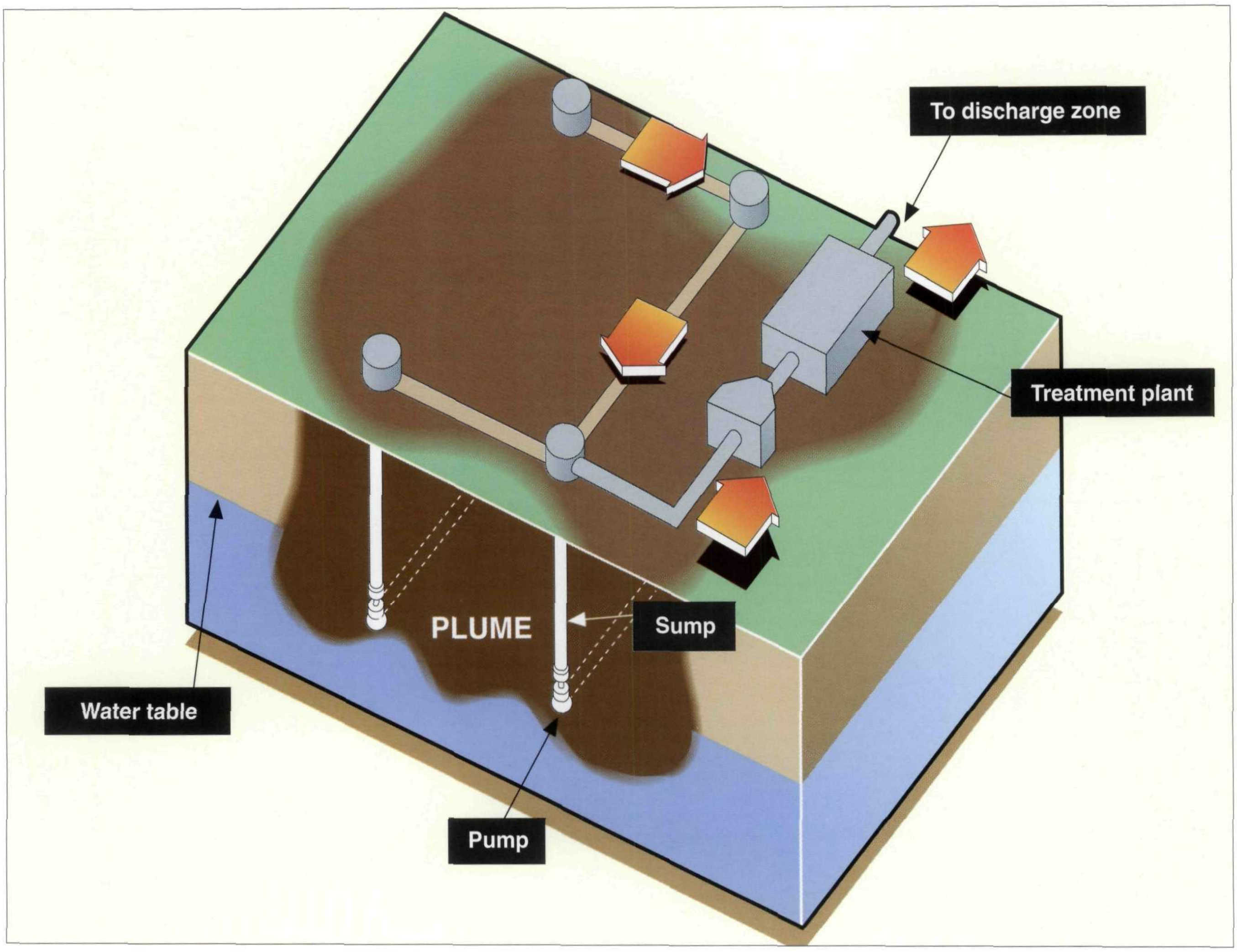
- interceptor trench – media treatment wall
- groundwater extraction
- exfiltration of treated effluent
- leachate containment/collection
- free-product recovery
- bioremediation, including bioventing
- soil flushing
- physical, chemical, and biological reactors
- soil vapor extraction
- air sparging
- aquifer dialysis

HORIZONTAL TECHNOLOGIES INCORPORATED

OUR NEW ADDRESS IS:
HORIZONTAL TECHNOLOGIES, INC.
4767 Pine Island Rd., NW
Matlacha, Florida 33993
Phone: (941) 283-5640 • Fax: (941) 283-2222

HERE'S HOW IT WORKS...

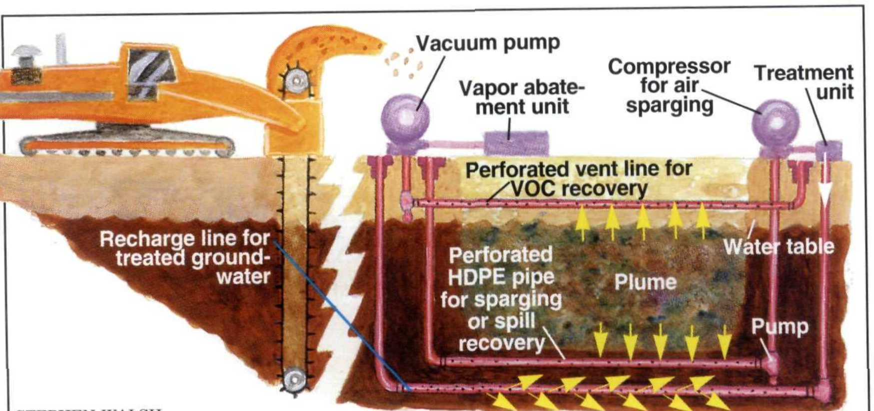
Horizontal Technologies, Inc. Linear Contaminant Remediation System



● The linear contaminant remediation system developed by Horizontal Technologies, Inc., Cape Coral, Fla., is a site specific installation of horizontal wells to recover contaminated groundwater from saturated soils without dewatering, generating a minimum of contaminated soil. A series of parallel wells are dug across a plume of contaminated groundwater by an installation machine that digs a 14-inch wide trench, lays perforated pipe in a saturated zone and a vapor recovery pipe in the vadose zone, then backfills with original soil or high hydraulic conductivity sand in one continuous operation. Contaminated water is drawn into the perforated pipe, then flows to a vertical sump where a submersible pump removes the water for aboveground treatment. The system can be used for soil flushing, vapor extraction, groundwater recovery, trenched air sparging or to deliver nutrients or bacteria for bioremediation. Vapor extraction from the unsaturated zone is accomplished with a vacuum recovery system. Treated water can be reintroduced to the site or disposed off site. A horizontal well can recover up to 1,000 gallons per minute in saturated strata, depending on well length and hydraulic conductivity of the formation. The system is appropriate for sites with unconsolidated strata (sands and clays) as the installation machine cannot penetrate hard rock, but, for such sites, pre-trenching with a backhoe enables placement of the system. Significant efficiencies have been proven for contaminants that are lighter than water, such as petroleum hydrocarbons. The installation is permanent and can be adapted for future monitoring of a site, or reactivated if necessary. It can be installed adjacent to, or even directly through contaminant plumes and recovers along its entire length, eliminating the problem of dead zones that occur between vertical wells in traditional installations. The installation machine, developed with components from Caterpillar, Inc., Peoria, Ill., has a trenching head girded to a rotating chain, and can lay pipe at an average rate of three to five feet per minute.

PROCESS PROFILE

HORIZONTAL PIPING GRID SPEEDS SITE CLEANUP



STEPHEN WALSH

Installing horizontal piping above, below or through a hydrocarbon plume or contaminated aquifer eliminates the "dead zones" that can occur between vertical wells. The piping network is permanent, so it can be adapted later for monitoring, or reactivated if another spill occurs

Gasoline, fuel oil, solvents and other hydrocarbons lost from tank farms or during transfer operations often end up as sources of soil and groundwater pollution. Such liquids tend to float as shallow plumes near the surface of the water table.

To recover these products, Horizontal Technologies, Inc. (Cape Coral, Fla.) offers the Linear Contaminant Remediation System (LCRS). It is a cost-effective alternative to traditional pump-and-treat systems, which use a series of vertical recovery wells.

The LCRS uses a horizontal network of perforated pipe to increase exposure to the spill. As a result, average recovery rates are 150 to 200 gal/min — a vast improvement over the 3-6 gal/min drawn by typical vertical wells. Recovery rates to 1,000 gal/min are possible, depending on well lengths and soil permeability, says president Don Justice.

In vertical recovery systems, each well has a narrow "cone of influence." As a result, vertical wells are typically installed in a densely spaced array (each with its own pump or delivery apparatus), to ensure adequate coverage of the contaminated area. This translates to higher capital costs and installation times than those of the LCRS.

In addition, vertical wells usually penetrate well into the water table (below the main body of contaminants), and pump water continuously to draw the contaminated plume toward the well. This produces large volumes of recovered groundwater to be treated.

By installing LCRS at a depth corresponding to the spill, "a richer broth" of hydrocarbons is captured without pumping excessive groundwater, says Justice. This reduces total treatment volumes and speeds site cleanup.

Swift, low-cost installation

Drains used in agricultural and irrigation applications have long relied on subsurface horizontal piping. However, excavation and installation can be labor intensive. To facilitate quick installation of the horizontal grid, HTI has developed a specialized machine in conjunction with Caterpillar, Inc. (Peoria, Ill.).

The vehicle (shown in the figure) digs a series of parallel 14-in.-wide trenches, lays in perforated pipe of high-density polyethylene (5, 6 or 8 in. dia.), and covers the trench with backfill — in one continuous motion. If soil permeability is relatively low, recovery rates can be improved by backfilling the trench with sand or gravel instead of excavated soil. Installation rates of 3-5 ft/min make the LCRS suitable for emergency response.

The horizontal piping is placed on a slight grade. Installed at the low end of each segment is an 8-in.-dia. vertical riser of non-perforated pipe, containing a submersible pump. As fluids collecting in the horizontal pipe (either hyrocarbon alone or tainted groundwater) flow toward these vertical risers, they are pumped to the surface. A 2-ply polyester sleeve (420-micrometer mesh) covers the perforated piping, keeping sand and silt from clogging the pipe or interfering with pump operation.

When air sparging is used to volatilize VOCs dissolved in the groundwater, contaminants can be removed as a vapor stream, again reducing total treatment volume. Any number of mobile remediation systems, including carbon filtration, steam stripping, bioremediation or incineration can be installed at the surface to treat the recovered stream.

Similarly, if the soil contains vapors of volatile organic compounds (VOC), a piping array can be installed in the nonsaturated soil above the spill. A vacuum pump at the surface delivers recovered soil vapors to the treatment system.

The LCRS can be installed to a maximum depth of 25 ft, although stepped or benched installations have been installed to 35-ft, says Justice. Segments of 180-ft pipe can be joined to create continuous lengths over 2,000 ft.

The swift, mechanized installation of the LCRS, and its higher recovery rates cuts site cleanup schedules and total remediation cost, says Justice. In more than 50 commercial installations to date where pump-and-treat systems were considered but LCRS was chosen, the horizontal grid was able to reduce contaminant levels to desired thresholds in a matter of weeks (as opposed to months), at a cost savings of 50%.

To control groundwater flow, isolate leaks from underground storage tanks or other spills, or enhance in situ treatment, HTI also offers the Polywall Barrier System. The firm's proprietary trenching vehicle digs a 14-in.-wide trench and unfurls a 40- to 100-mil HDPE membrane from a 180-ft roll, at a depth to 30 ft.

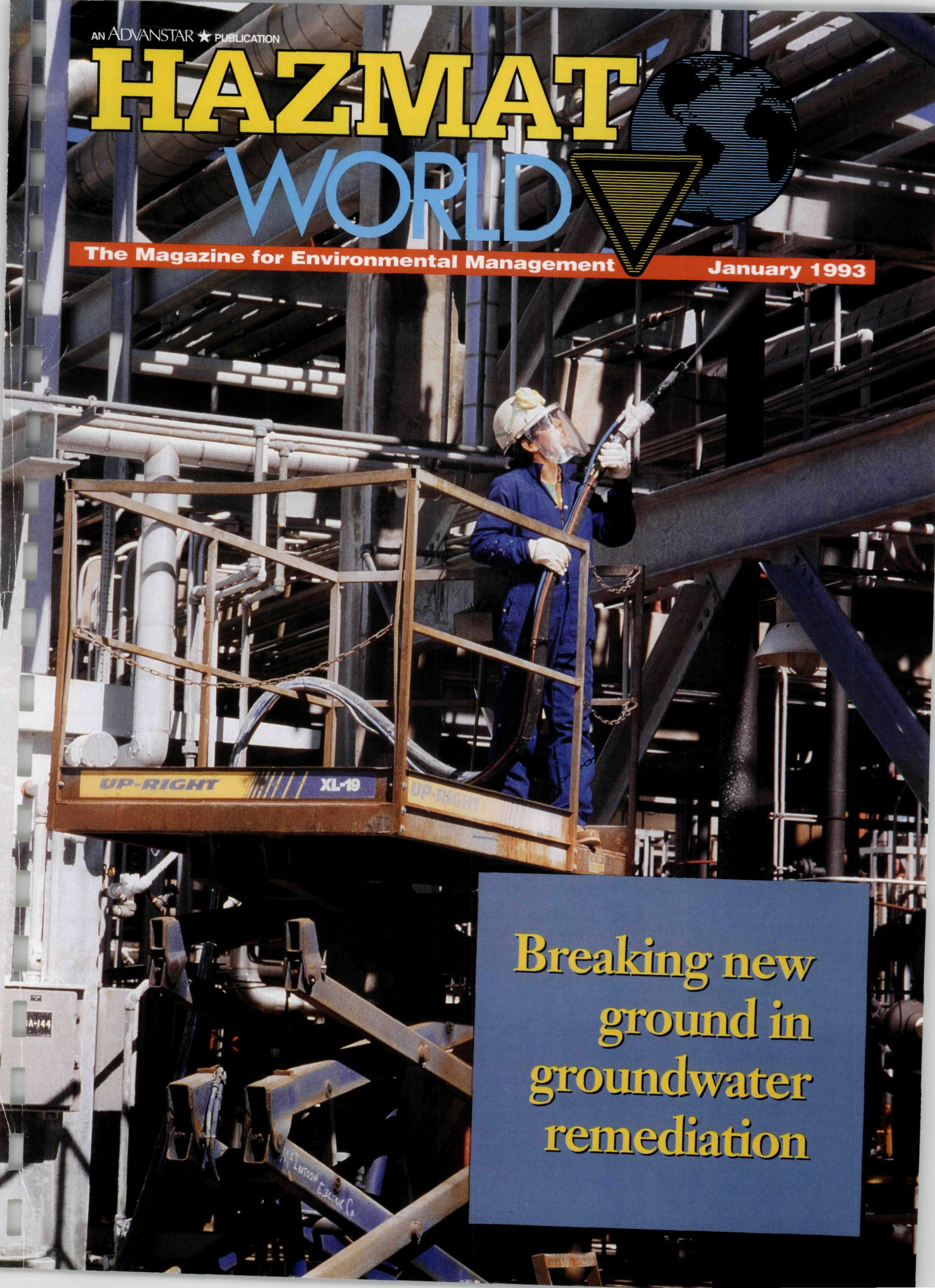
Since the only heat-welded seams in this subsurface barrier are formed where successive rolls are joined, the number of potential leakage points is minimized. Conventional subsurface barriers are typically installed as a series of 4-ft panels, whose many welded seams create numerous potential leakage pathways. — *Horizontal Technologies, Inc. (Cape Coral, Fla.)*

AN ADVANSTAR ★ PUBLICATION

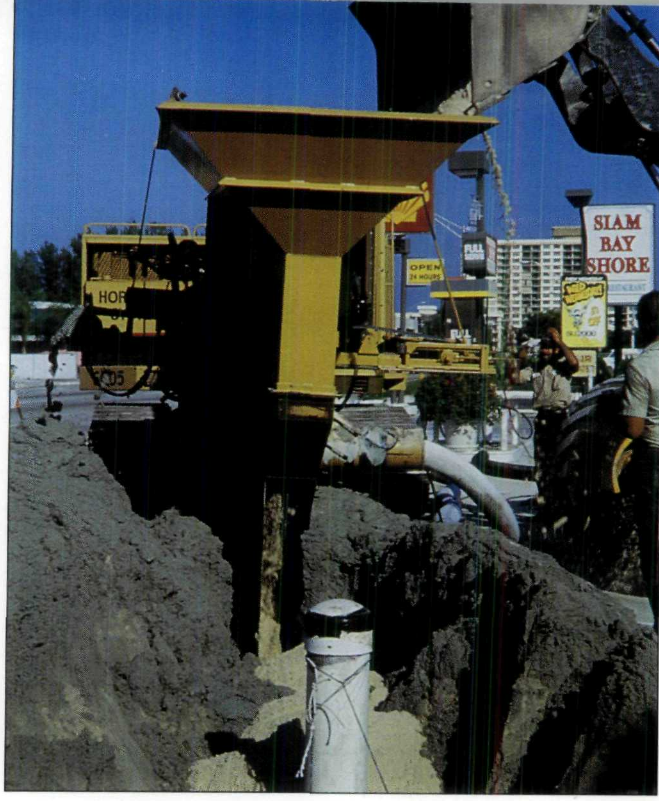
HAZMAT WORLD

The Magazine for Environmental Management

January 1993



Breaking new ground in groundwater remediation



Breaking new ground in groundwater remediation

BY MARYBETH FARRELL

MANY ENVIRONMENTAL REMEDIATION EXPERTS believe a large portion of their industry's future lies just below the surface — in the nation's polluted aquifers.

EPA estimates that more than 1.5 million underground petroleum storage tanks exist in the United States, excluding the tens of thousands containing home heating oil, which are not subject to federal regulation. Since 1988, state environmental agencies have reported to EPA more than 166,000 incidents involving leaking underground petroleum storage tanks, and continue to report an additional 50,000 new releases each year, relates John M. Heffelfinger, environmental protection specialist and team leader in the Agency's Office of Underground Storage Tanks. By the mid-1990s, he continues, EPA estimates states will have identified more than 300,000 USTs leaking petroleum products into soil and groundwater.

Today, groundwater is contaminated at more than 85 percent of the 1,207 NPL sites. Additionally, EPA estimates that drinking water at 73 percent of these sites is tainted with chemicals considered dangerous to human health.

With more than half of all Americans — about 125 million people — obtaining their drinking water from underground aquifers, it seems obvious why EPA considers groundwater pollution one of the nation's greatest environmental hazards.

Traditional methods of recovering and treating contaminated groundwater have been limited almost entirely to vertical well techniques. These techniques involve using high-pressure drills to bore vertical wells over a contaminant source and pumping contaminants to the surface for treatment.

Originally developed by the oil industry for petroleum recovery, vertical wells are the most widely available and commonly used technique for soil and groundwater contamination. However, like other traditional approaches to environmental remediation, vertical wells are losing ground to new technologies that are improving on the speed, effectiveness and cost of existing systems.

One such technology involves horizontal wells, which also were developed by the oil industry for petroleum extraction.

"Typically, to clean up groundwater, vertical extraction wells are installed because the technology is available, and (because) well installation is relatively inexpensive," says Richard T. Eades, senior hydrogeologist at Midwest Research Institute (MRI; Cary, N.C.). MRI is a non-profit organization that provides support to EPA's Office of Solid Waste and Emergency Response, and Office of Underground Storage Tanks.

"Trying to capture groundwater by using vertical wells is like putting straws in a bathtub and pulling the plug," Eades says. "Think about it. The chance that a contaminant, such as gasoline, will escape capture by vertical extraction wells is pretty good, especially between wells. If you install horizontal wells, you can capture or contain contaminants more effectively."

Banking that others agree with Eades' assessment, Horizontal Well Systems (HWS;

Developers claim Horizontal Well Systems' patented technology can achieve cost savings from 50 percent to 70 percent of traditional horizontal and vertical well systems.

Cape Coral, Fla.) has developed a unique technology that takes horizontal wells a step beyond existing systems. A division of Horizontal Dewatering Systems Inc. (HDSI; Cape Coral, Fla.), HWS is seeking to carve out a market niche with a system designed to improve the time, efficiency and cost of surficial groundwater remediation.

Don Justice, founder of HDSI and HWS president, originally designed the system to improve dewatering at construction sites, and later found it useful for beach erosion and irrigation applications.

In all, Justice holds seven patents relating to the HWS system, including U.S. Patent 4,927,292, which covers the process as well as the equipment. Other patents cover specific equipment components, including the trenching tool for installing perforated pipe, the wastewater drainage and recovery system, the corrugated drainage tube, the coupling device, and the leachate containment system. A separate patent covers various applications, including lake level control, agricultural recovery and reuse, remote fire protection, domestic water recovery and reuse, and a commercial system that recycles site runoff from initial rainfall. In addition, five patents are pending for other uses, including *in situ* groundwater and soil bioremediation, and thermally enhanced vapor extraction.

Justice says he believes the technology will out-perform and "out-price" the best vertical and horizontal well systems available for recovering and treating contaminated surficial groundwater. "It's no exaggeration to say that the HWS system is going to revolutionize the cleanup of contaminated groundwater in surficial water tables," he asserts. "This system does a faster and more thorough job of remediation at a fraction of the cost of other wells on the market."

Justice says the HWS system can address 80 percent of the market for contaminated surficial groundwater. It is especially suitable for groundwater remediation at gasoline and oil storage tank farms, gasoline stations, and landfills, he says, because a lateral installation into the water table collects contaminants more efficiently and in greater volume than vertical wells.

An inside look. The centerpiece of the HWS system is its patented trenching machine. Developed in conjunction with Caterpillar Inc.'s (Peoria, Ill.) Industrial Products Division, the machine features a proprietary convertible riser with a vertical well and trenching head. In one continuous step, it digs a trench up to 20 feet deep, installs a vertical well with a built-in submersible pump, lays a flexible horizontal wellscreen (recovery pipe) and backfills with original dirt. Sites do not have to be dewatered before the well is installed, which provides additional cost savings.

The system's trenching head consists of steel cutters girded to a rotating elliptical chain. The installation process begins when the machine chews a 14-inch-wide hole straight down to a maximum depth of 20 feet. The vertical well is carried by the trenching head and installed through a patented hydraulic release mechanism. This first step takes about five minutes.

The vertical riser is connected to the horizontal wellscreen by a patented coupler, which enables the horizontal, high-density polyethylene (HDPE) pipe to be linked to the vertical polyvinyl chloride (PVC) pipe.

From the vertical well installation point, the machine can dig either forward or backward. As it digs, it lays an HDPE perforated wellscreen at an average rate of 3 to 5 feet per minute. The wellscreen is perforated uniformly around its surface to permit balanced water flow into the pipeline. It is covered with a permeable, double-ply, polyester and glass filter that prevents clay, sand and silt from clogging the wellscreen or pumping system. The protective filter also can be made of more durable materials, depending on the soil and environmental conditions. As water collects in the wellscreen, it flows to the vertical well, where the submersible pump directs it to a site-specific treatment system.

The wellscreen is placed at established, site-specific grades and is encapsulated in filter gravel packs. It is available in continuous lengths up to 180 feet. Segments can be joined to create custom installations longer than 2,000 feet.

In general, Justice says, the HWS system costs about half that of a horizontal well bore system, while savings over a vertical well system can be as great as 70 percent. At a Charlotte, N.C., site, for example, initial cleanup plans for thousands of gallons of groundwater contaminated by a hydrocarbon spill called for 100 vertical wells at a cost of $1 million. HWS ultimately was selected to clean up the spill at a cost between $300,000 and $350,000, he relates.

Justice says the HWS system offers significant improvements in cleanup efficiency and effectiveness. It can pump up to 100 times as much water as a vertical well system, he says. In saturated soils, a vertical well typically recovers 3 to 6 gallons per minute, he continues, while the HWS system can recover 150 to 300 gallons per minute, or about 50 times the volume.

At an abandoned municipal fuel storage facility in Tamarac, Fla., where petroleum products had contaminated underground water supplies, cleanup originally was supposed to take 30 months using 41 vertical wells. The HWS system remediated the site in eight weeks using nine horizontal wells.

"I don't know of anyone who does things quite the way his (Justice's) system does," says Dawn Kaback, a leading researcher on horizontal wells for groundwater and soil remediation. Kaback is manager of the Geotechnical Group, Savannah River Technology Center at DOE's Savannah River site in Aiken, S.C., where she is leading a team of researchers investigating new applications for horizontal well technologies for *in situ* remediation of soil and groundwater.

A review of the HWS technology indicates it does "speed cleanup," Kaback says, adding, "I think there's a lot of potential for it."

In addition to cost savings, the system also is flexible and mobile, making it well-suited to emergency response situations, Justice says. In the spring of 1992, for example, the HWS system assisted in remediating 30,000 gallons of spilled gasoline from a Florida water table.

Containment of toxic chemicals at a site until they can be removed is another important component of remediation, Justice continues. The 20-foot trenches dug by the HWS system serve as containment walls, he says, whose effectiveness can be enhanced with the addition of gravel or sand. The company's most recent patent (No. 5,118,230) covers a plastic liner that reduces further the potential for offsite migration of contaminants.

"Containment is a major market area," agrees MRI's Eades, "and the horizontal well has a tremendous market advantage over vertical wells in containing contaminants, particularly those that float on the water table, like most petroleum products."

Mark D. Nickelson, chief scientist for the Hazardous Waste Remediation Program (HazWRAP) at Martin Marietta Energy Systems Inc. (Oak Ridge, Tenn.), says his preliminary review indicates the technology is promising. "We think installation is quicker, probably cheaper and probably has fewer technical problems," he says.

The HWS system also is creating interest in agricultural and recreational irrigation circles, where it has been applied to extract surficial water once considered virtually unrecoverable. It has been installed at six golf courses and more than 20 agricultural sites in Florida, including the University of Florida's Institute of Food and Agricultural Sciences (Fort Pierce, Fla.).

Beyond irrigation uses, the system's delivery and extraction capabilities can be linked to a variety of technologies, including adsorption, air sparging, bioremediation, bioventing, chemical treatment, delivery-extraction systems, soil flushing, materials handling and soil-vapor extraction. It can be used in combination with these systems for installation above and below shallow plumes of contaminated groundwater and soils.

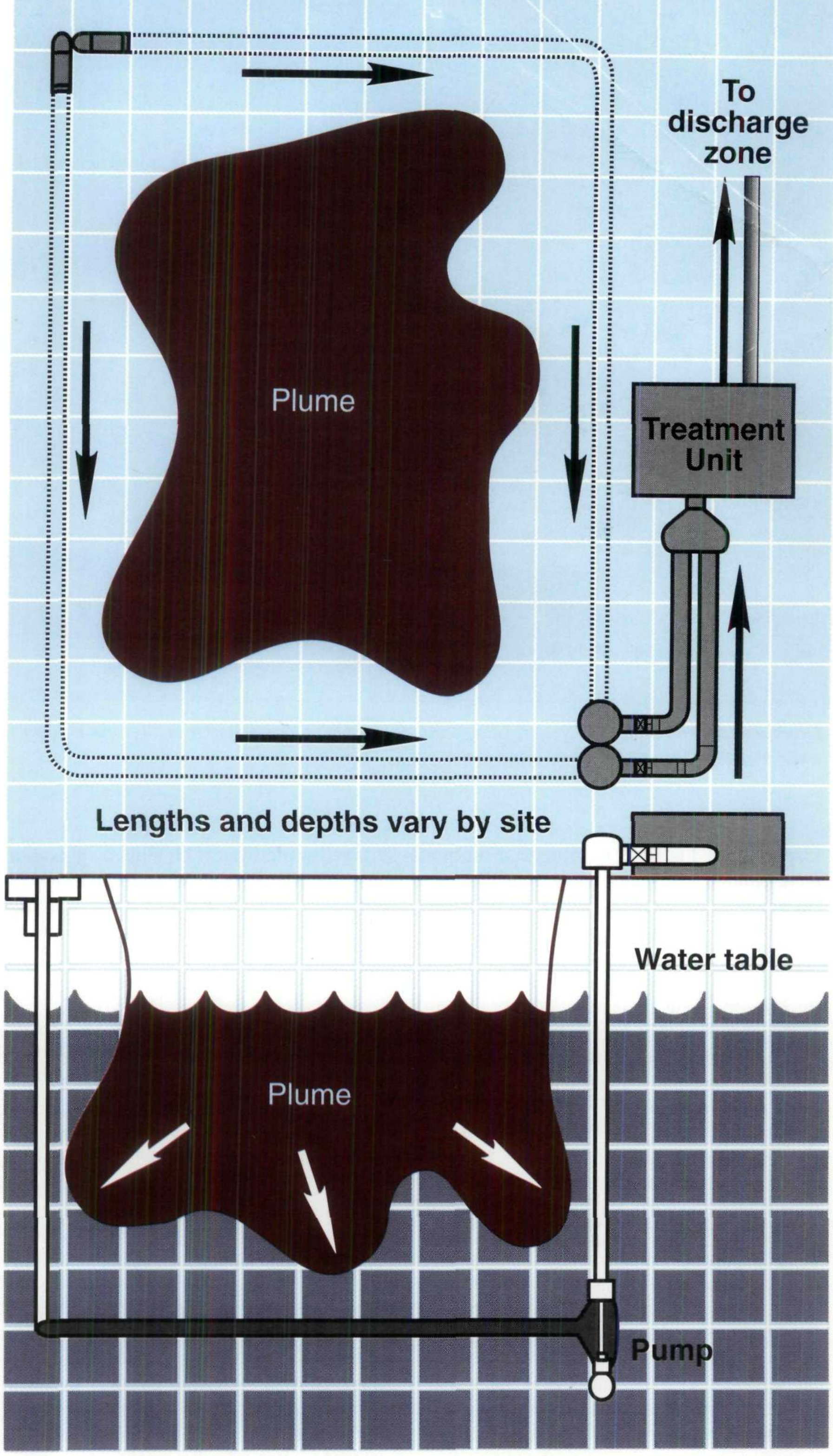
Besides technical efficiency, Justice says the HWS system virtually eliminates worker exposure to contaminants, because it precludes the need for workers to lay pipe manually in contaminated ditches. It also causes less disruption to the environment, he says, and reduces offgassing of dangerous chemicals, such as benzene, typically found in soil contaminated by petroleum products.

Despite its many benefits, however, Justice concedes that the technology is not suitable for all sites. For example, he says, the trenching head cannot penetrate bedrock, or drill beneath buildings or landfills. Its size can impede navigation through the spider web of underground pipelines, wires and utility cables, potentially limiting its use in urban areas. Also, the machine only can reach a depth of 20 feet, possibly limiting its application.

In spite of these limitations, Eades says the sum of the system's unique features constitutes substantial innovation. "I know it can work," he says. "I've heard the testimony of others, and horizontal wells can offer improvement over conventional interceptor trench installations done the old way, where it took longer, and where workers risked more exposure when they had to handle the soil twice."

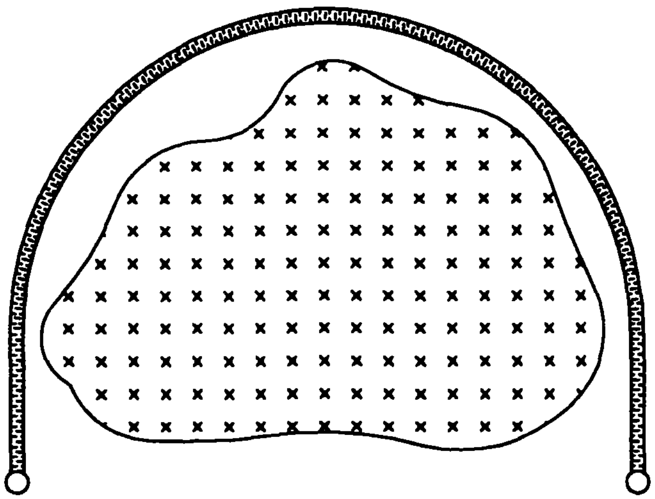
HDSI plans to make the HWS system available on a nationwide basis in late 1993. ▼

Typical layout of horizontal well around plume of contamination



Contamination Remediation Applications

- ▲ Free Product Recovery
- ▲ Dissolved Phase Recovery
- ▲ Soil Vapor Extraction
- ▲ Air Sparging
- ▲ Bioremediation
- ▲ Groundwater Flow Control
- ▲ Aquifer Dialysis



DIRECT CONTAINMENT
LEACHATE COLLECTION

Horizontal Technologies, Inc. P.O. Box 150820 Cape Coral, FL 33915	PROJECT:		
	TITLE: LCRS		
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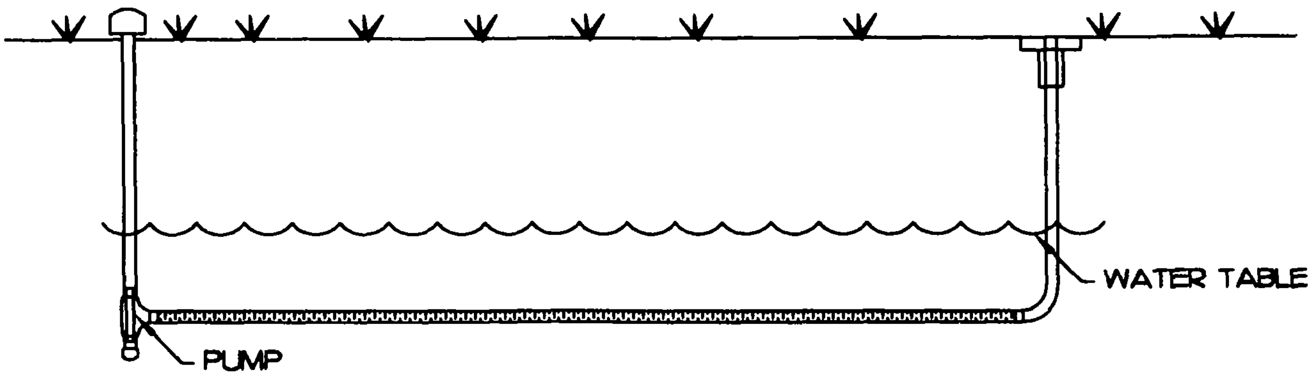
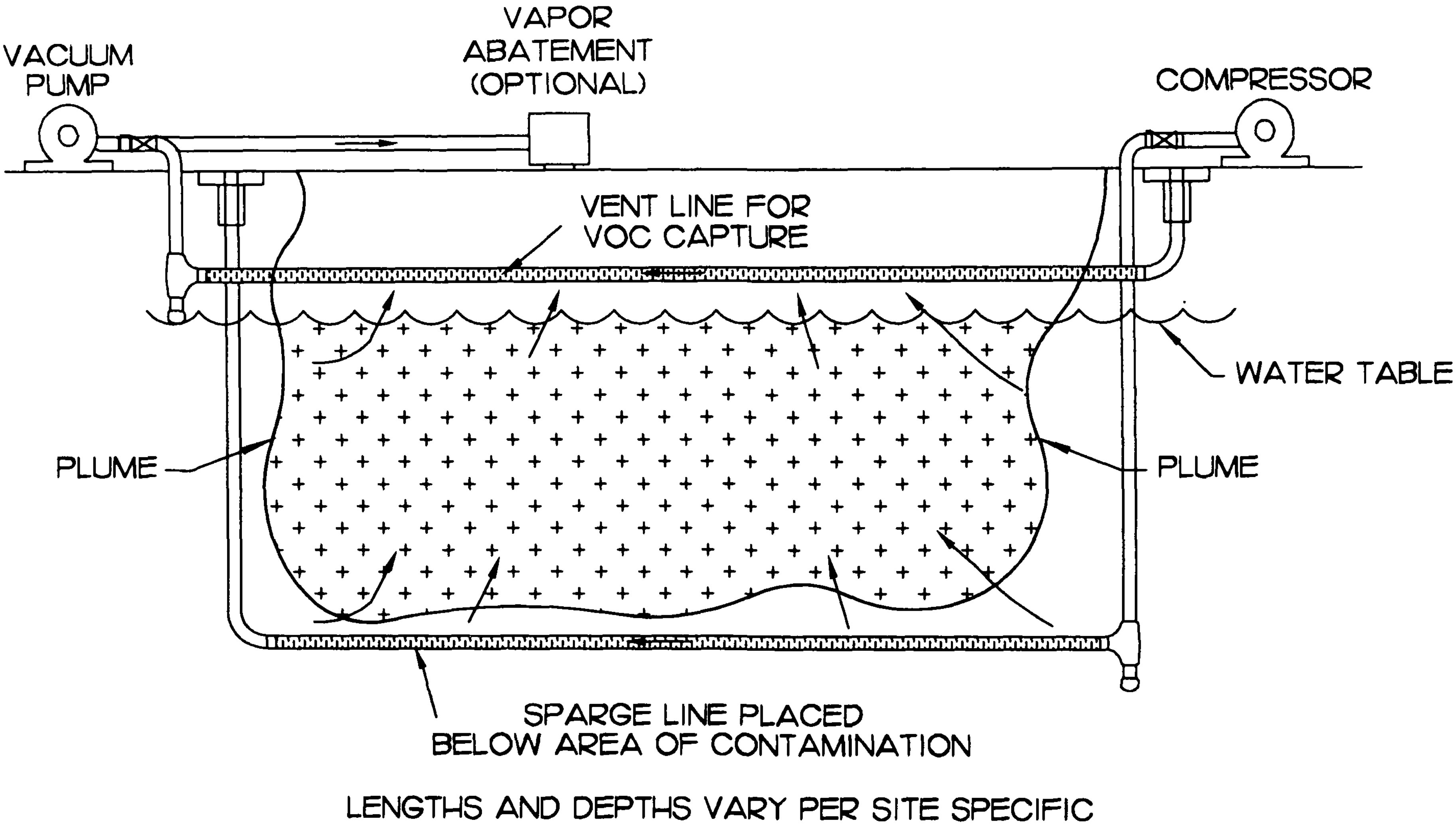


GROUND WATER RECOVERY

Horizontal Technologies, Inc.
P.O. Box 150820
Cape Coral, FL 33915

PROJECT:	
TITLE:	LCRS

DRAWN BY:	DATE:	PLATE:
BGG	1/22/94	REM5



HTI

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P.O. Box 150820
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PROJECT:

TITLE: Sparging

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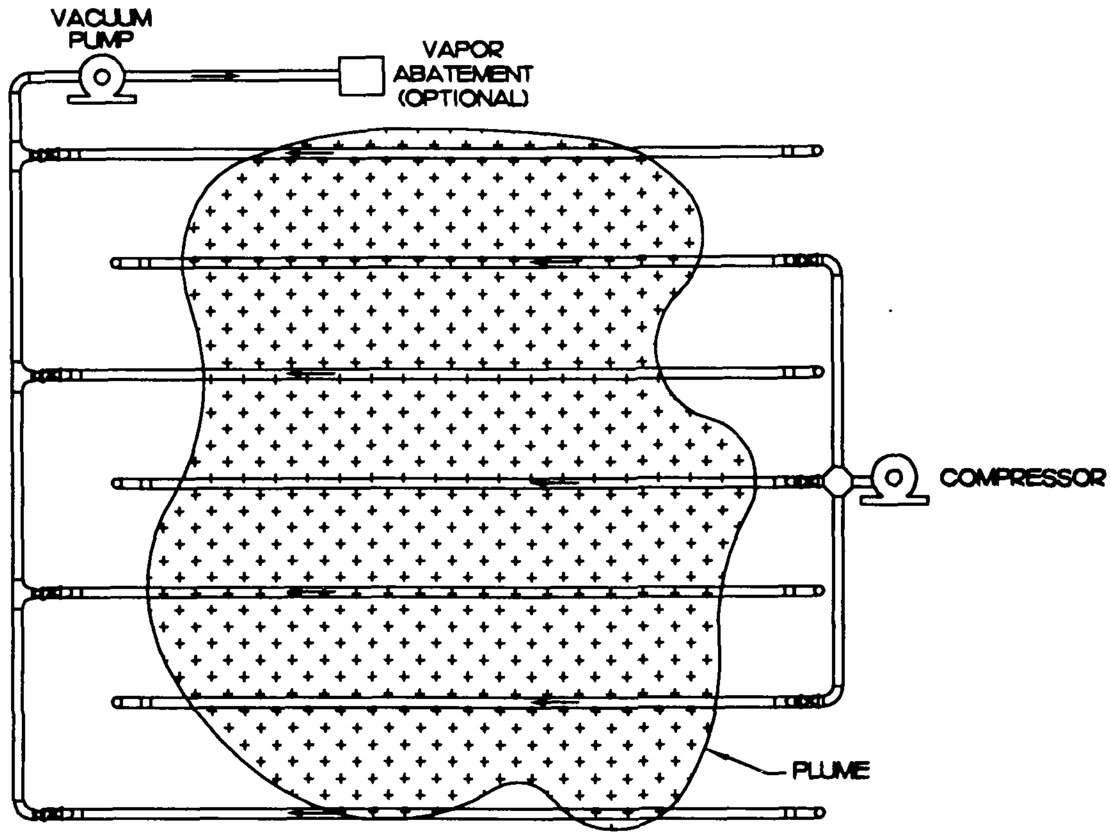

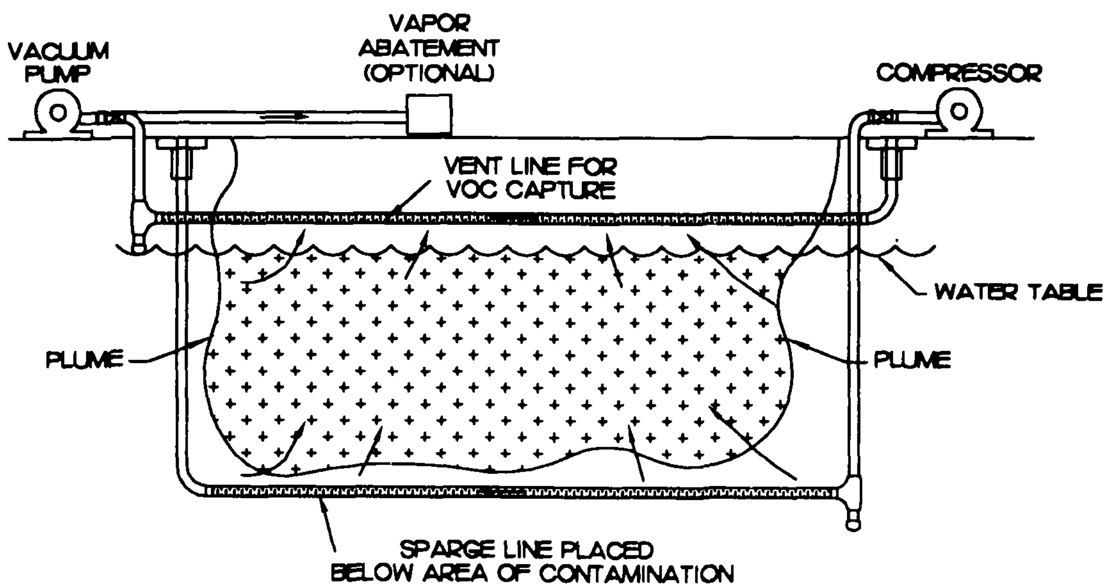

LENGTHS AND DEPTHS VARY PER SITE SPECIFIC

PROJECT:	
TITLE:	LCRS
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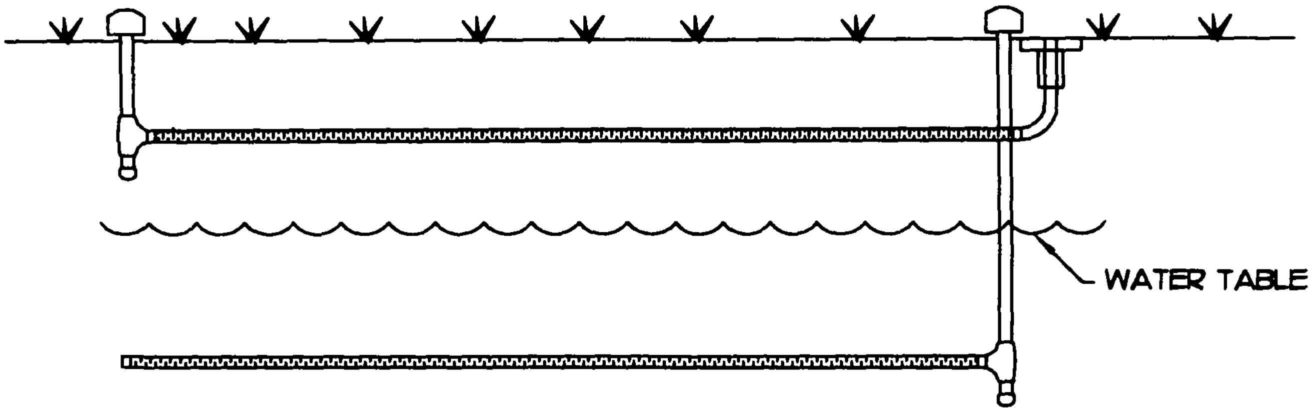
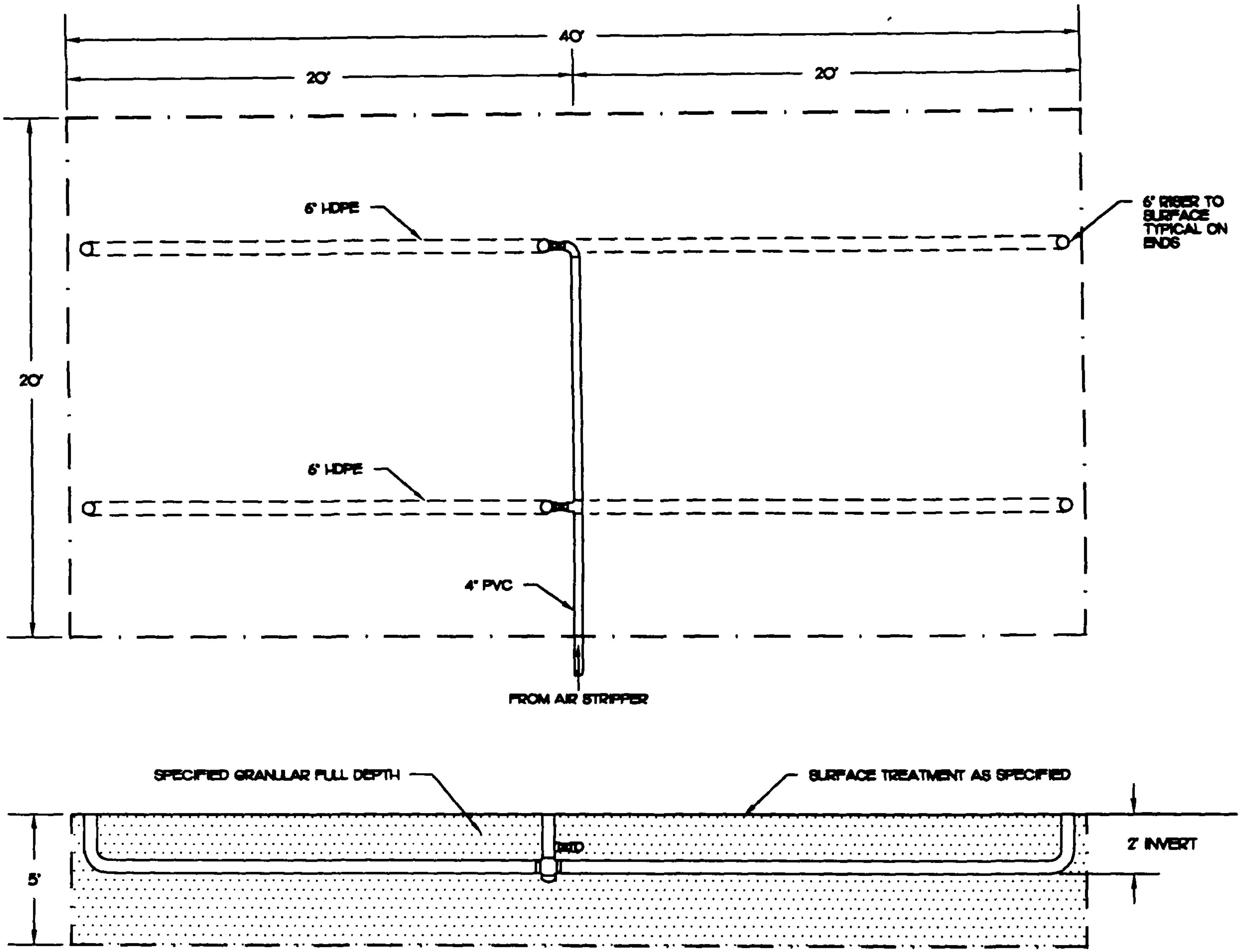


SPARGING

Horizontal Technologies, Inc.
P.O. Box 150820
Cape Coral, FL 33915

PROJECT:	
TITLE:	LCRS

DRAWN BY:	DATE:	PLATE:
BGG	1/22/94	REM3



Horizontal Technologies, Inc.
P.O. Box 150820
Cape Coral, FL 33915

PROJECT:

TITLE: Horizontal Recharge Line

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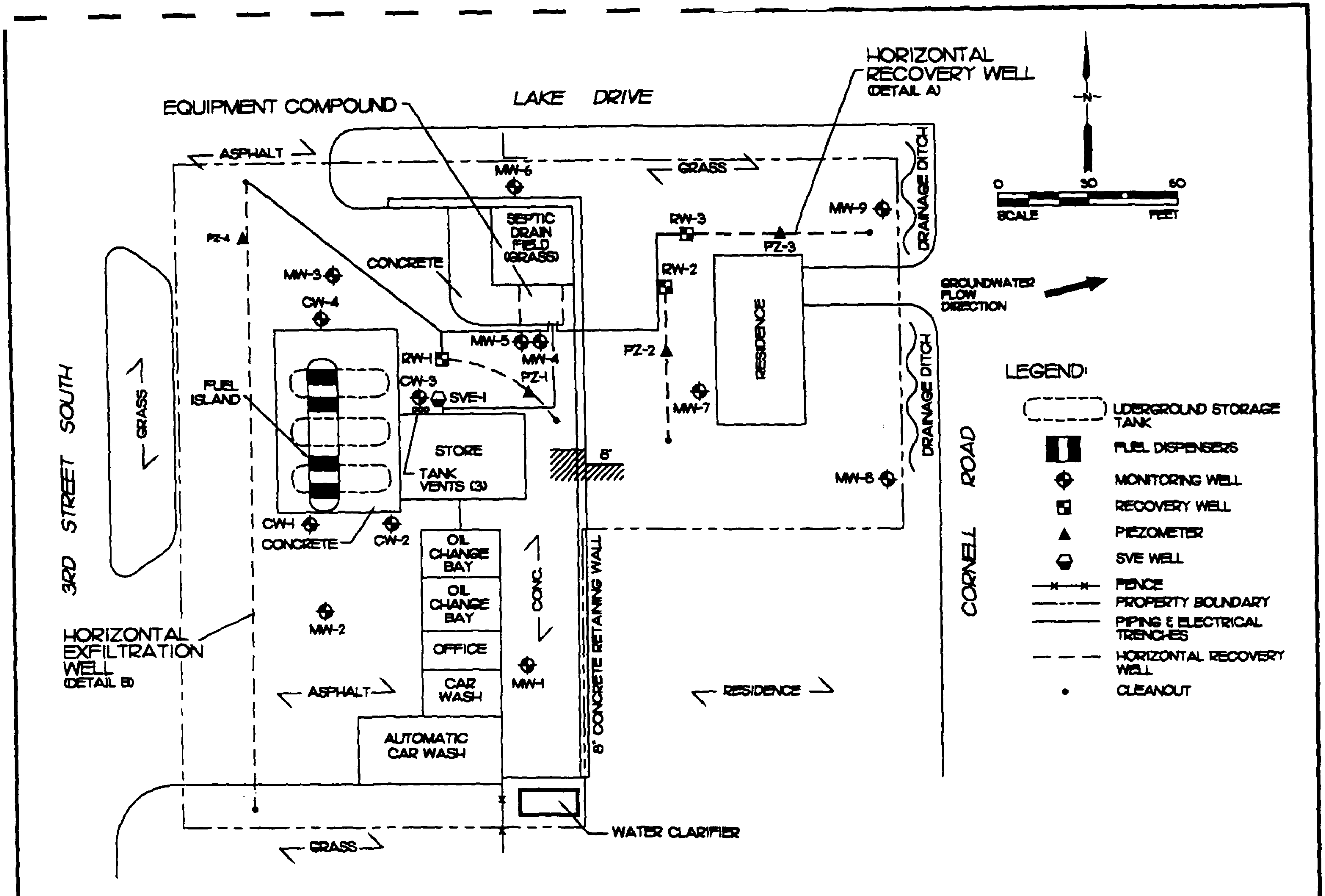
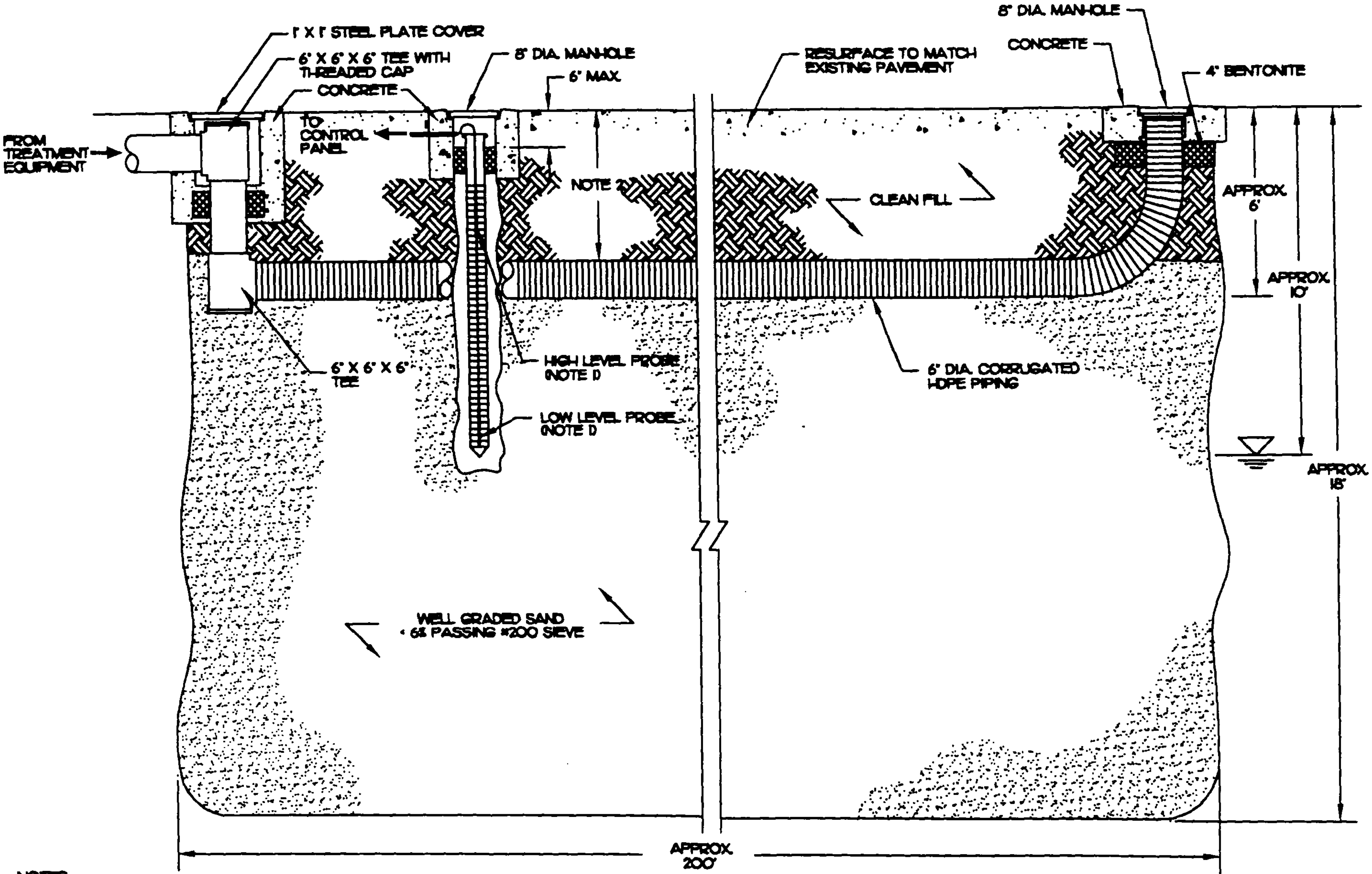


Horizontal Technologies, Inc.
P.O. Box 150820
Cape Coral, FL 33915

PROJECT:	Corner Gas Station
TITLE:	Site Layout

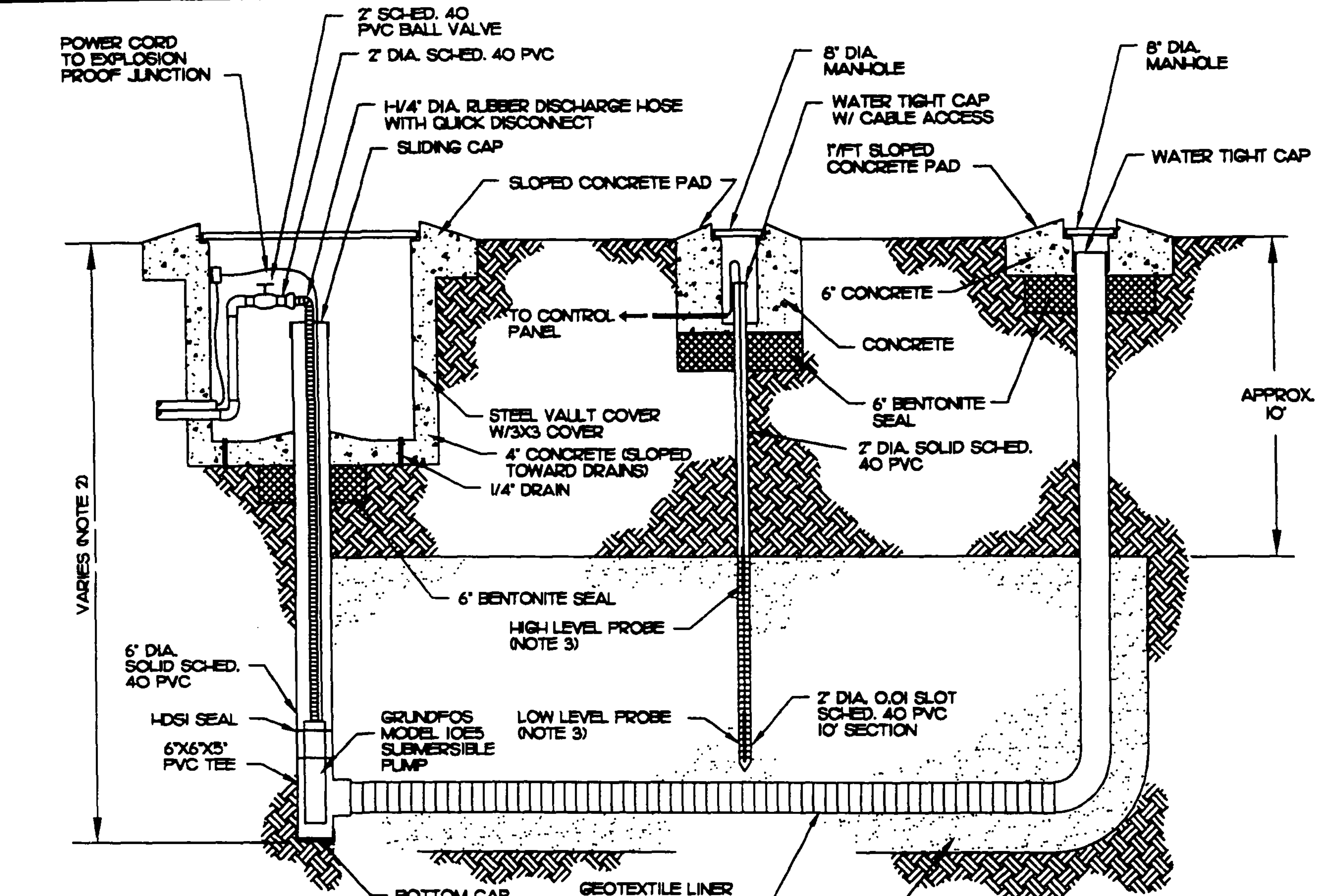
DRAWN BY:	DATE:	PLATE:
BGG	3/1/94	REM20



NOTES:
1.) LEVEL PROBES POSITIONED IN FIELD
2.) DEPTH TO BE APPROX. 2' BELOW SURFACE. 0.0125 FT/FT SLOPE.

ELEVATION VIEW: DETAIL B (NOT TO SCALE)

HTI	Horizontal Technologies, Inc. P.O. Box 150820 Cape Coral, FL 33915	PROJECT: Corner Gas Station
		TITLE: Horizontal Exfiltration Well System
		DRAWN BY: BGG / DATE: 3/1/94 / PLATE: REM21



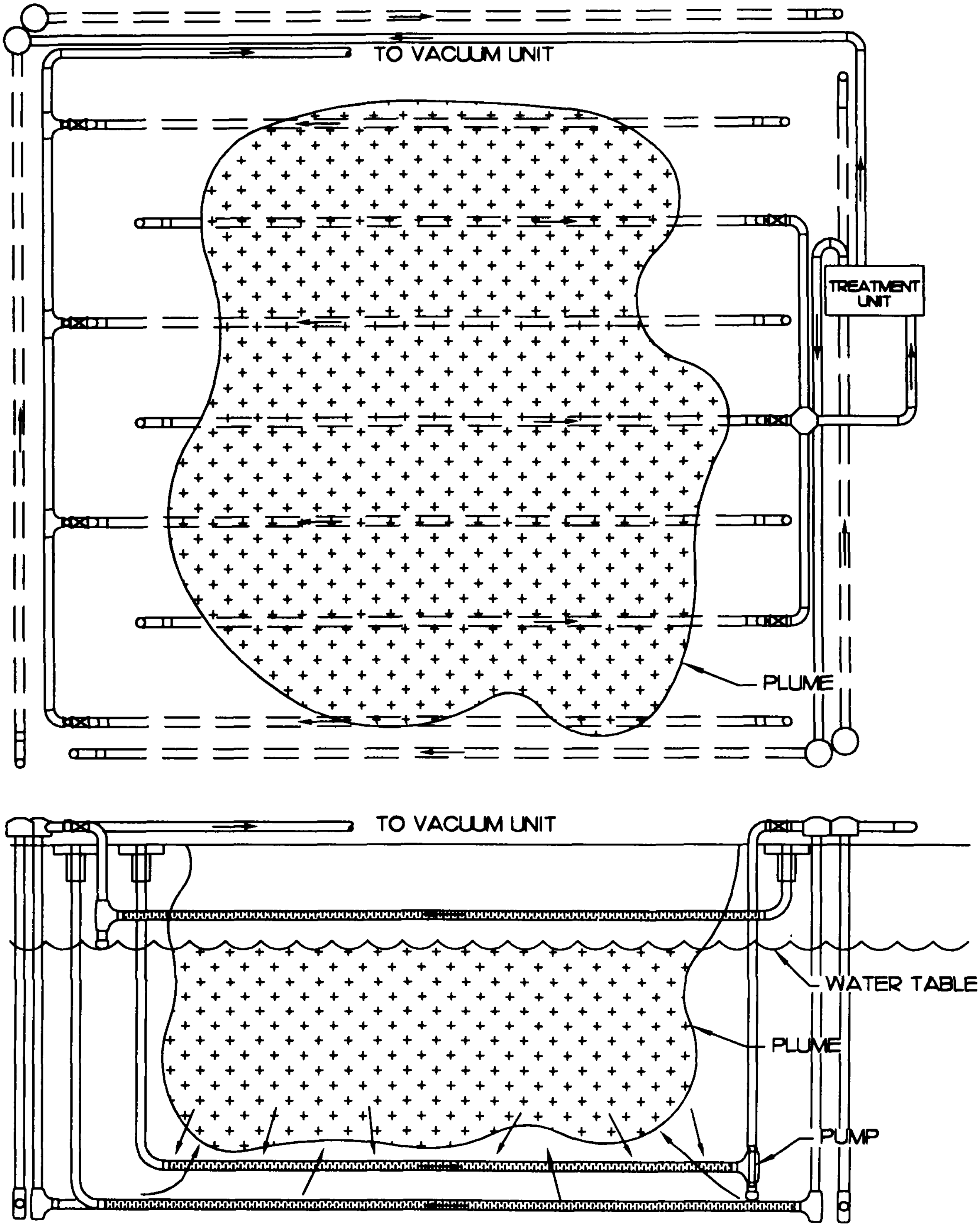
NOTES:
1) TRENCH LENGTH DEPENDENT ON RECOVERY WELL
2) 25 FT. BELOW GRADE REFERENCE TO MW-5 TOP OF CASING
3) LEVEL PROBES POSITIONED IN FIELD

ELEVATION VIEW: DETAIL A (NOT TO SCALE)

Horizontal Technologies, Inc.
P.O. Box 150820
Cape Coral, FL 33915

PROJECT:	Corner Gas Station
TITLE:	Horizontal Recovery Well System

DRAWN BY:	DATE:	PLATE:
BGG	3/1/94	REM22



LENGTHS AND DEPTHS VARY PER SITE SPECIFIC

HTI
Horizontal Technologies, Inc.
P.O. Box 150820
Cape Coral, FL 33915

PROJECT:	
TITLE:	LCRS

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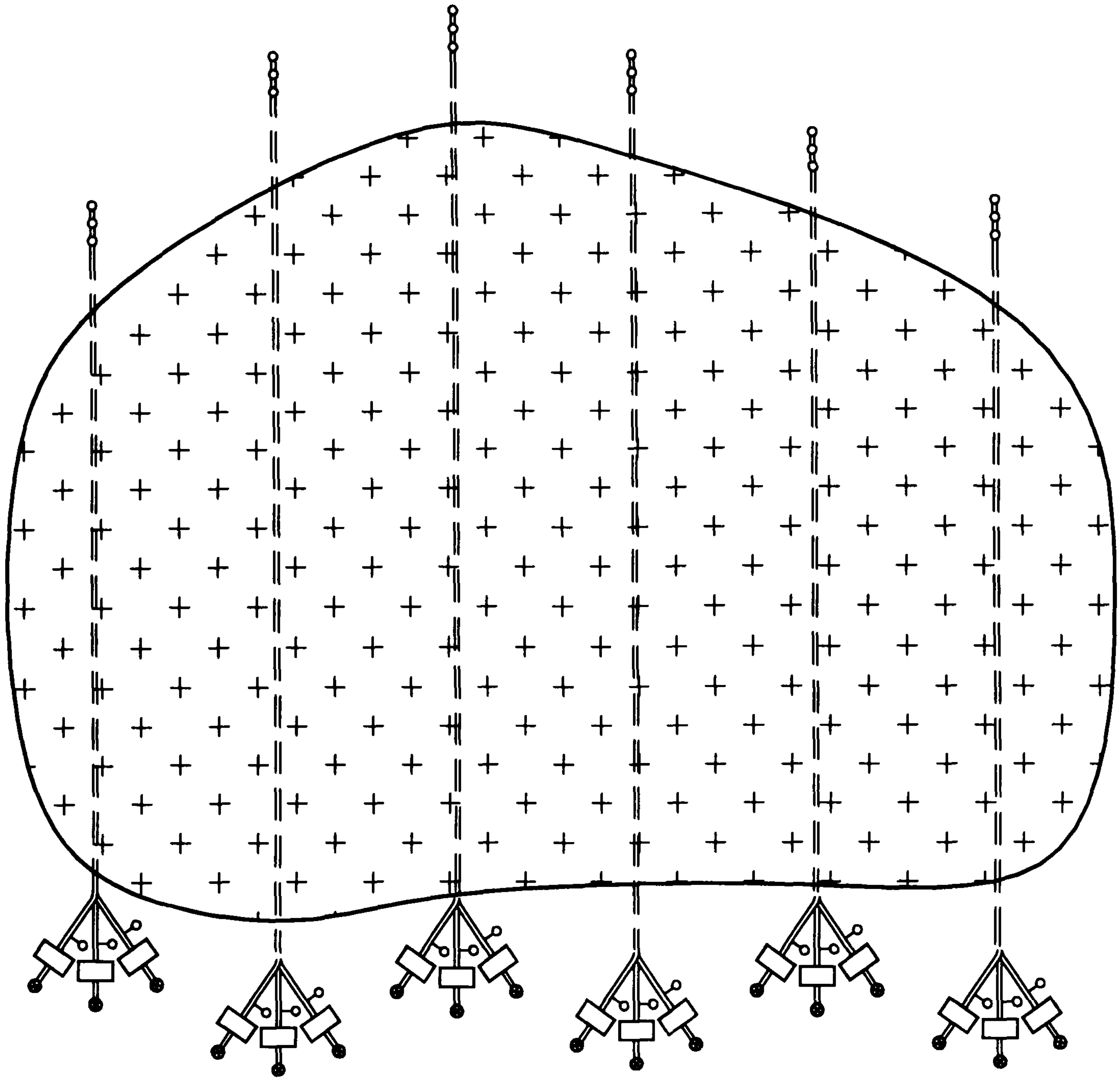


LEGEND

CONTAMINATED GROUNDWATER

HORIZONTAL WELL

REVERSABLE FLOWMETER & TOTALIZER

ADJUSTING VALVE

SAMPLE PORT

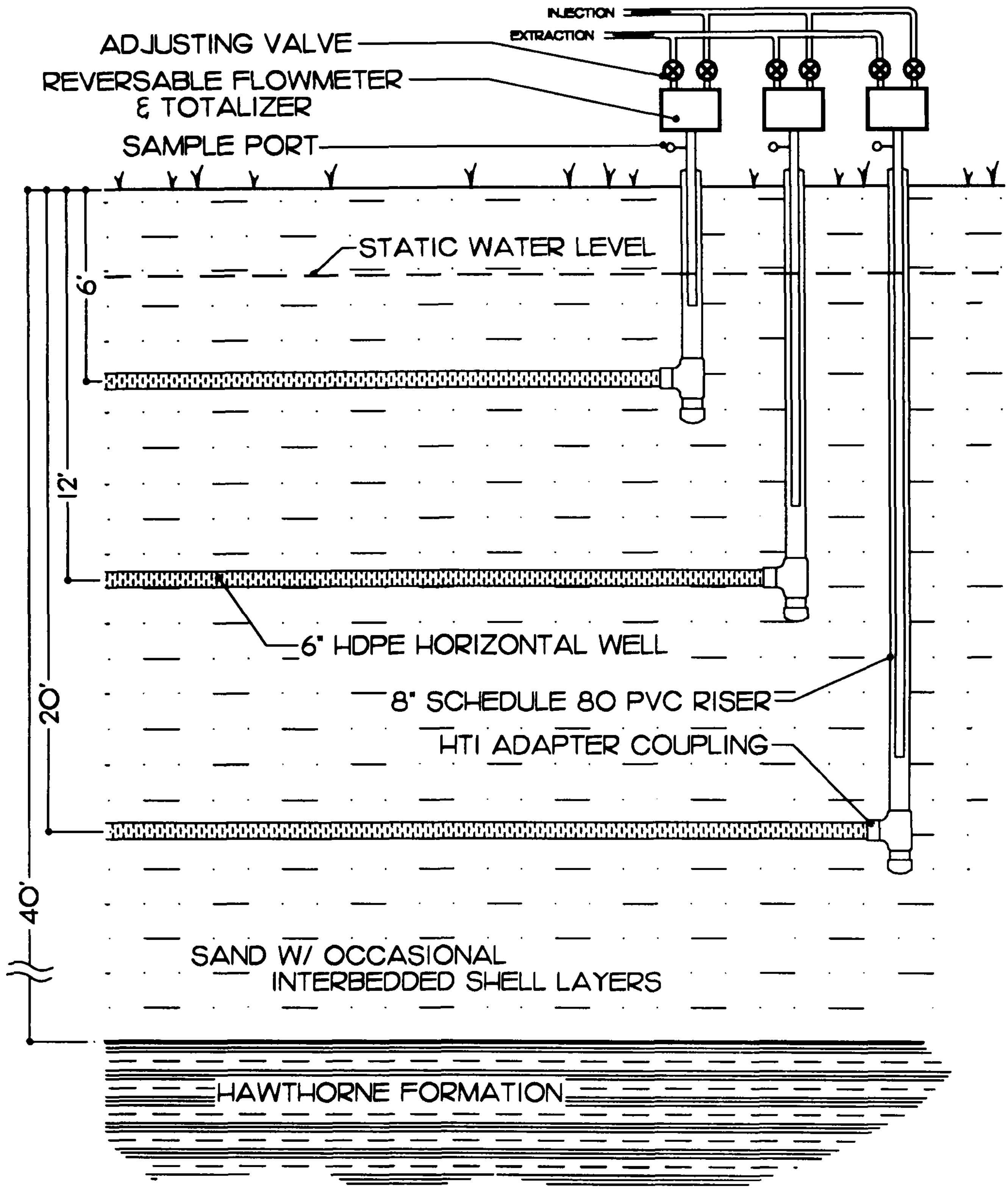
CLEANOUT

Horizontal Technologies, Inc.
P.O. Box 150820
Cape Coral, FL 33915

PROJECT:

TITLE: L.C.R.S. Site Dialysis – Plan View

DRAWN BY: [signature] | DATE: 1/14/94 | PLATE: LCRS01



HTI	Horizontal Technologies, Inc. P.O. Box 150820 Cape Coral, FL 33915	PROJECT:	
		TITLE: L.C.R.S. Site Dialysis Cross Section - Side View	
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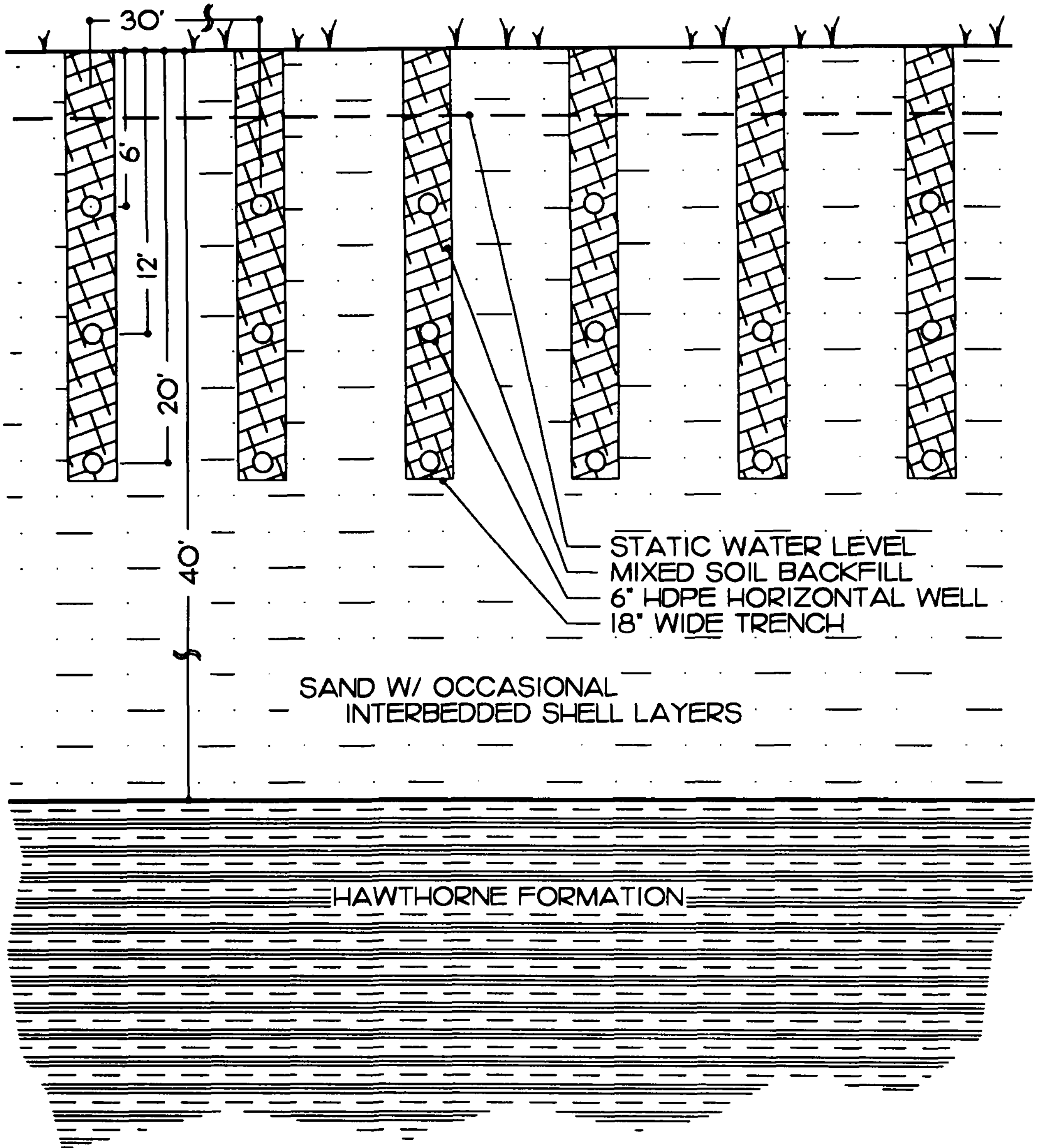

Horizontal Technologies, Inc.
P.O. Box 150820
Cape Coral, FL 33915

PROJECT:

TITLE: L.C.R.S. Site Dialysis Cross Section - End View

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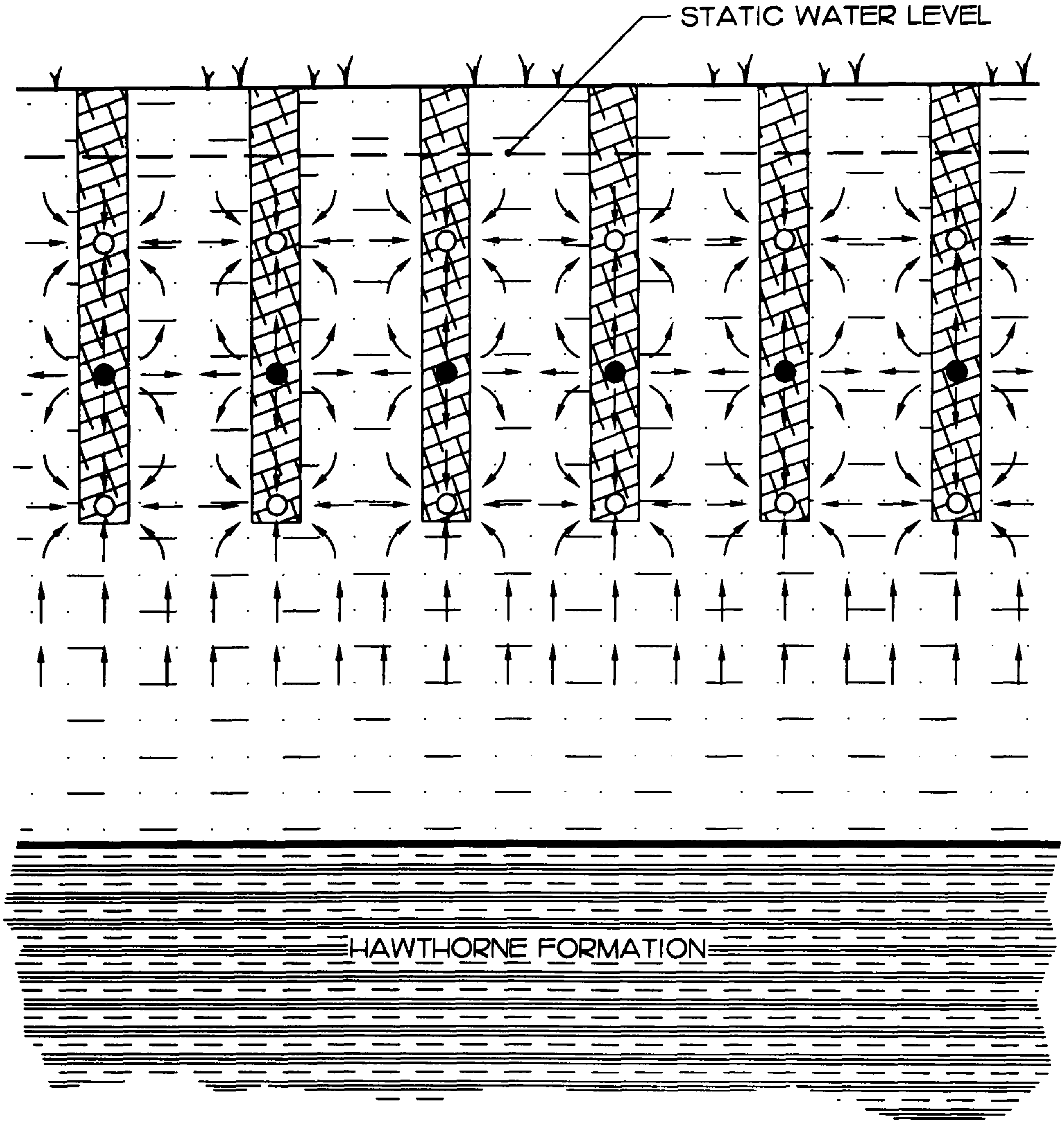
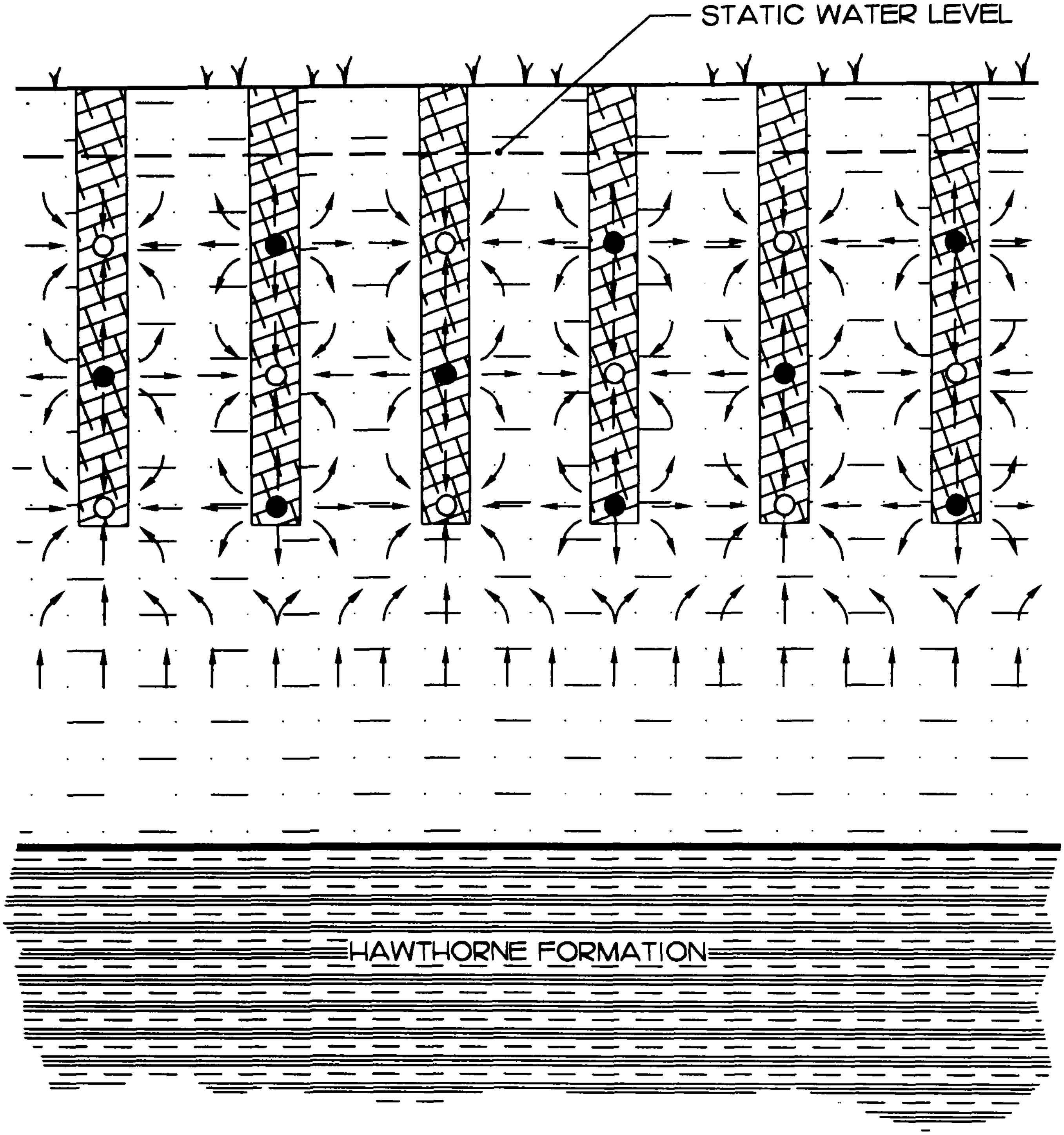


○ HORIZONTAL WELL VALVED FOR EXTRACTION
● HORIZONTAL WELL VALVED FOR INJECTION
FLOWPATH

Horizontal Technologies, Inc.
P.O. Box 150820
Cape Coral, FL 33915

PROJECT:	
TITLE:	L.C.R.S. Site Dialysis Cross Section - End View w/ Flow Lines (A)

DRAWN BY:	DATE:	PLATE:
	1/15/94	LCRS04



○ HORIZONTAL WELL VALVED FOR EXTRACTION
● HORIZONTAL WELL VALVED FOR INJECTION
↖ FLOWPATH

Horizontal Technologies, Inc.
P.O. Box 150820
Cape Coral, FL 33915

PROJECT:	
TITLE:	L.C.R.S. Site Dialysis Cross Section - End View w/ Flow Lines (B)

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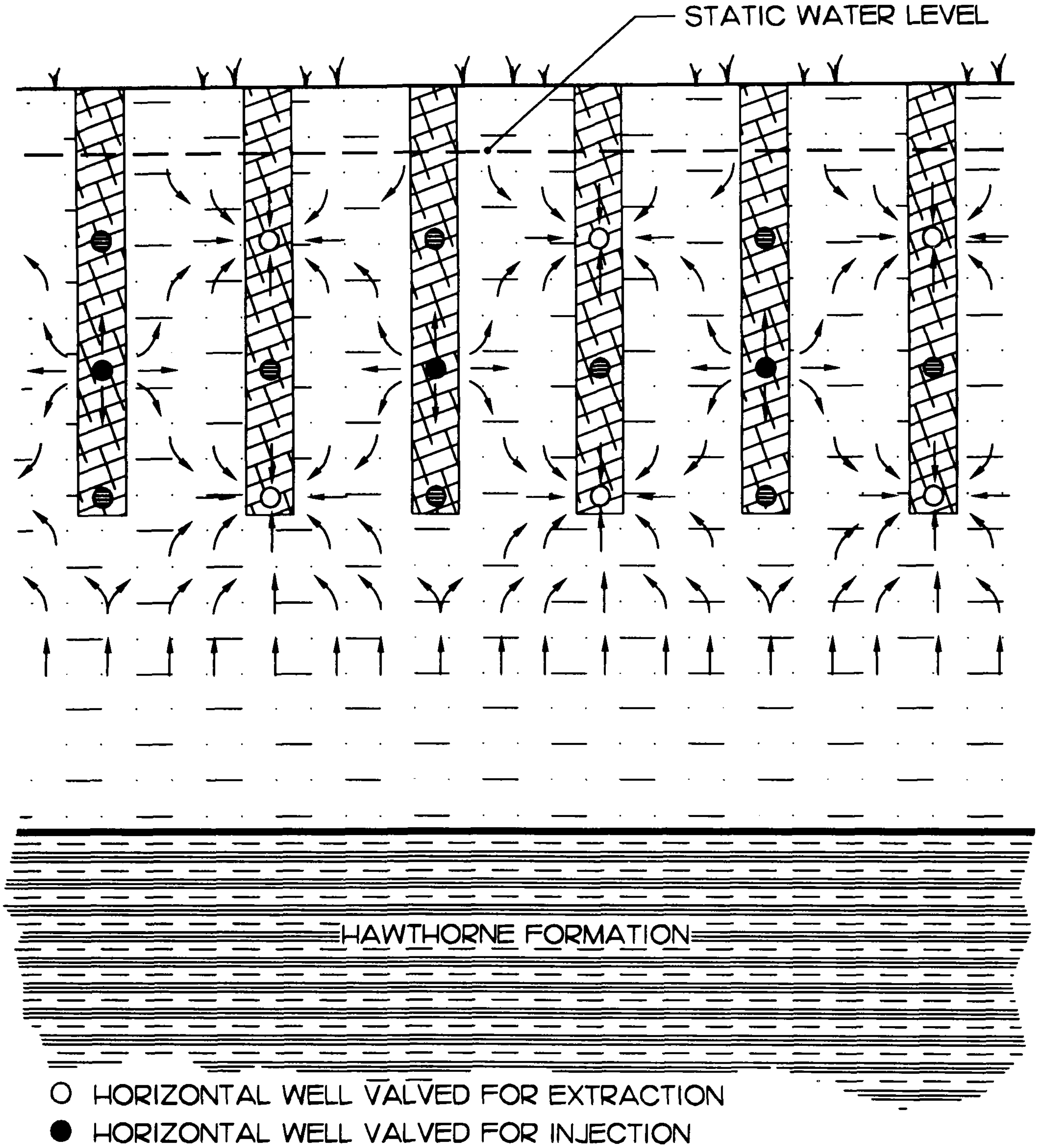

○ HORIZONTAL WELL VALVED FOR EXTRACTION
● HORIZONTAL WELL VALVED FOR INJECTION
⊜ HORIZONTAL WELL - IDLE
↖ FLOWPATH

Horizontal Technologies, Inc.
P.O. Box 150820
Cape Coral, FL 33915

PROJECT:

TITLE: L.C.R.S. Site Dialysis Cross Section - End View w/ Flow Lines (C)

DRAWN BY: [signature] | DATE: 1/15/94 | PLATE: LCRS06

Significant Cost Savings

- ▲ Faster Remediation Times
- ▲ More Efficient Capture of Contaminants
- ▲ Reduced Capital Costs for Treatment Equipment
- ▲ Reduced Operation and Maintenance Costs
- ▲ Reduced Monitoring Costs
- ▲ Reduced Effluent Disposal Costs

US005252226A

United States Patent [19]

Justice

[11] Patent Number: 5,252,226

[45] Date of Patent: Oct. 12, 1993

[54] LINEAR CONTAMINATE REMEDIATION SYSTEM

[76] Inventor: Donald R. Justice, 5260 S. Landings Dr., Ft. Myers, Fla. 33919

[21] Appl. No.: 882,228

[22] Filed: May 13, 1992

[51] Int. Cl.[5] B01D 19/00; E21B 7/00

[52] U.S. Cl. 210/739; 175/62; 210/188; 210/747; 210/805; 405/128

[58] Field of Search 405/128, 36; 210/96.1, 210/143, 170, 188, 739, 747, 749, 805, 806; 175/57, 62

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5,118,230	6/1992	Justice	405/128

Primary Examiner—Joseph W. Drodge

Attorney, Agent, or Firm—Jacobson, Price, Holman & Stern

[57] ABSTRACT

A series of horizontally extending drainage pipes forming a grid system are located at or below the level of a plume of liquid contamination. The drainage recovery pipes skim off the surface of the water table, along with the plume of contamination. This minimizes the time required for removal of water that needs to be pumped from the ground and cleaned. Once the contaminant is pumped from the ground, it is delivered to a conventional treatment system where it is cleaned and then the cleaned water is returned back to the ground water table. This cleaned water is reintroduced over the grid system and is drawn through the soil to flush out any remaining contaminants in the soil. Once the treated water reaches the water table, the liquid contaminants are usually less dense than water and rise towards the surface of the water table. The contaminants are then removed by the grid system for treatment.

17 Claims, 8 Drawing Sheets

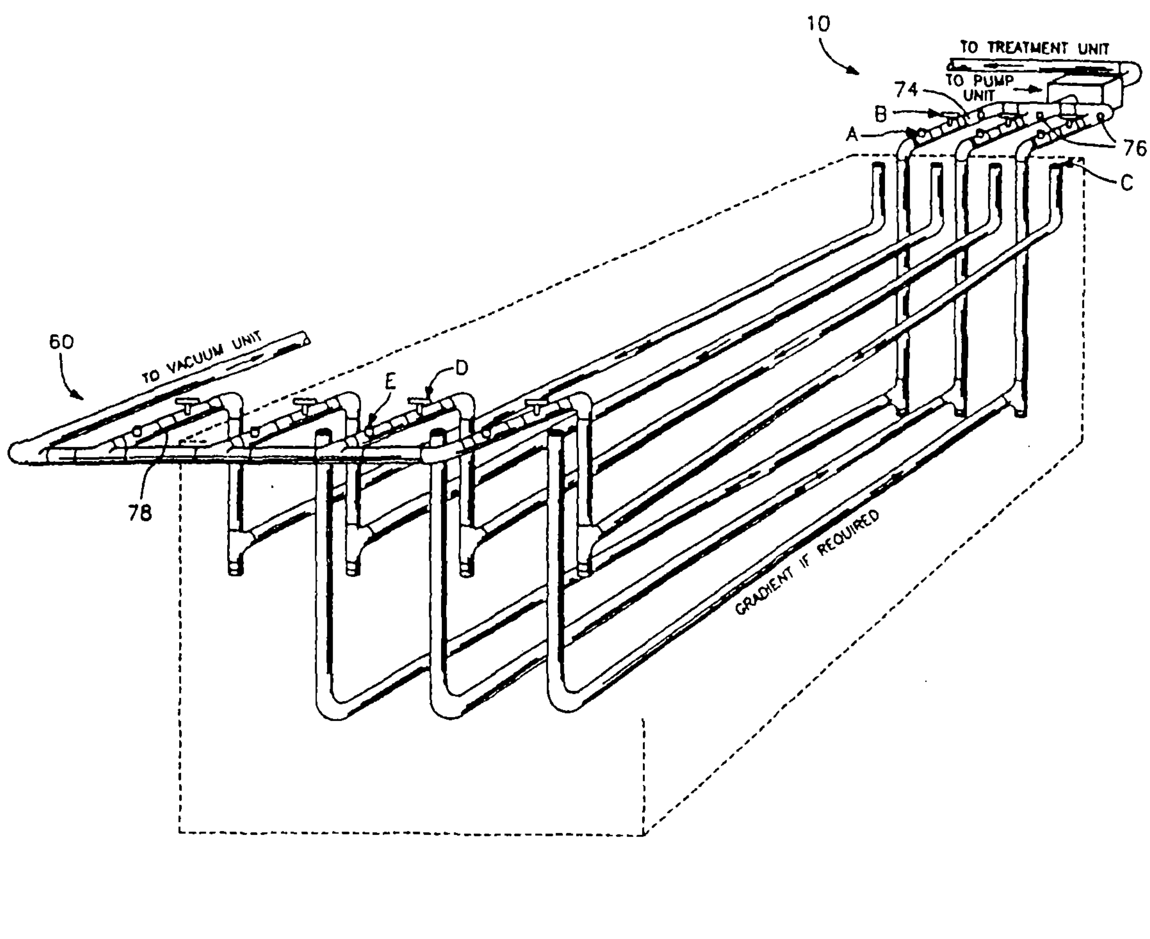


FIG. 1

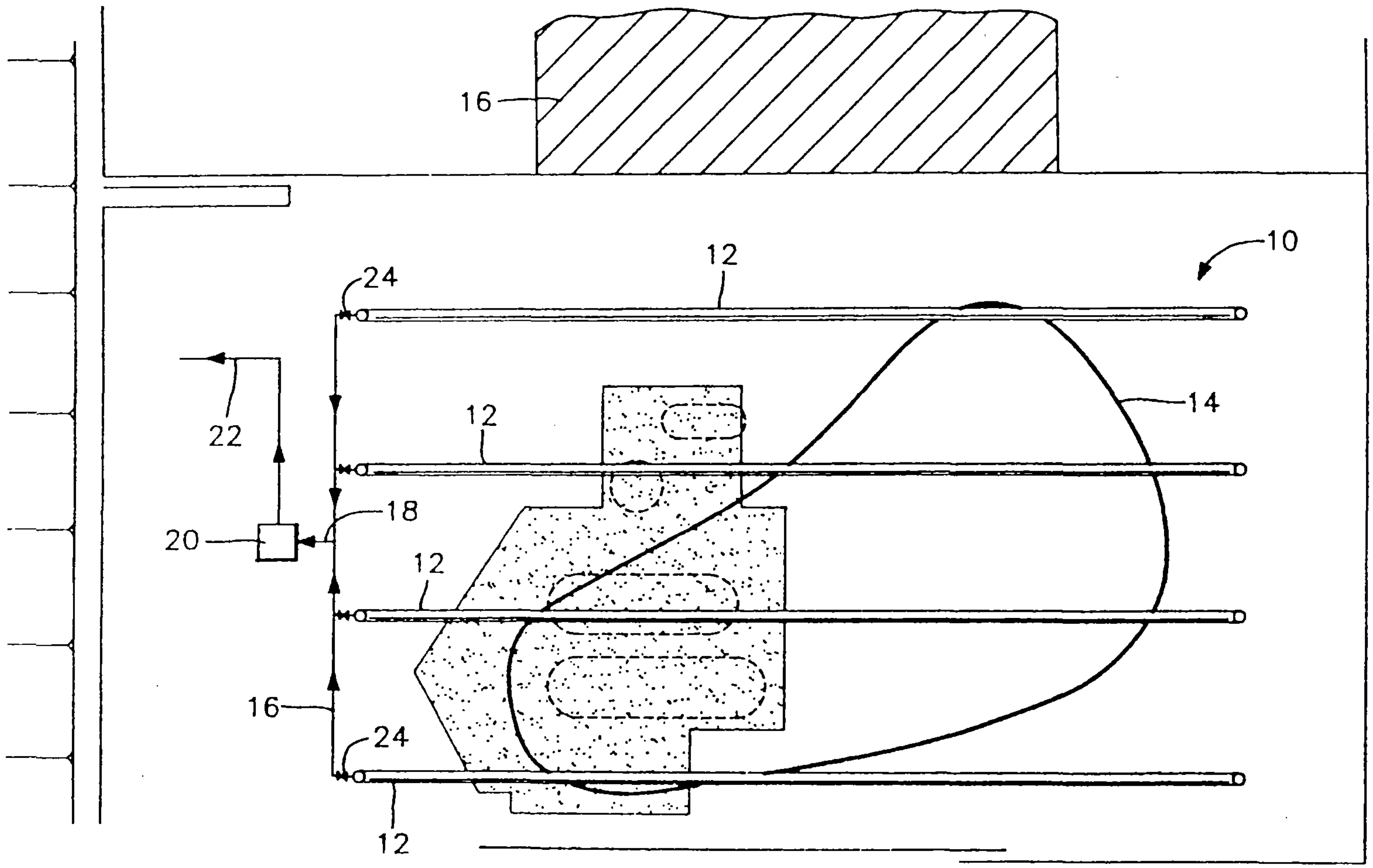


FIG. 2

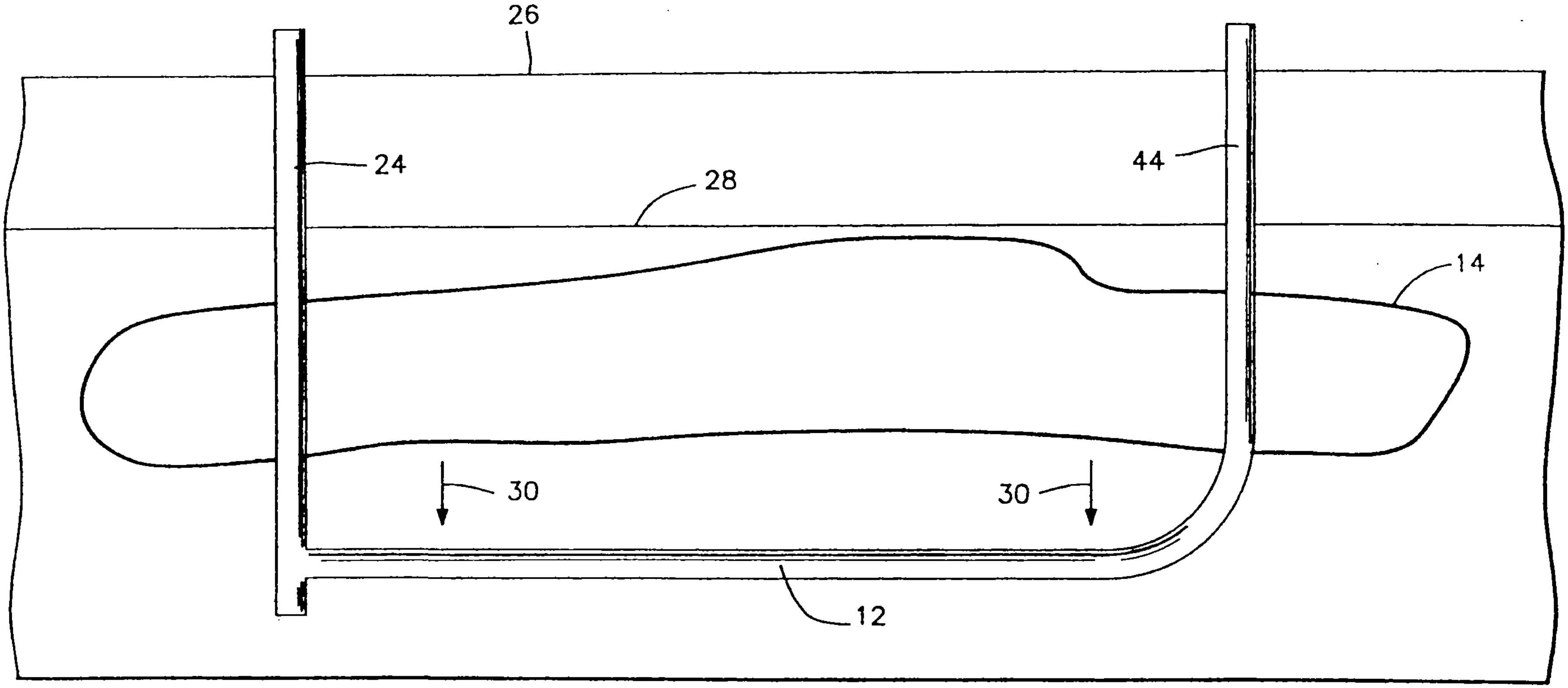


FIG. 3

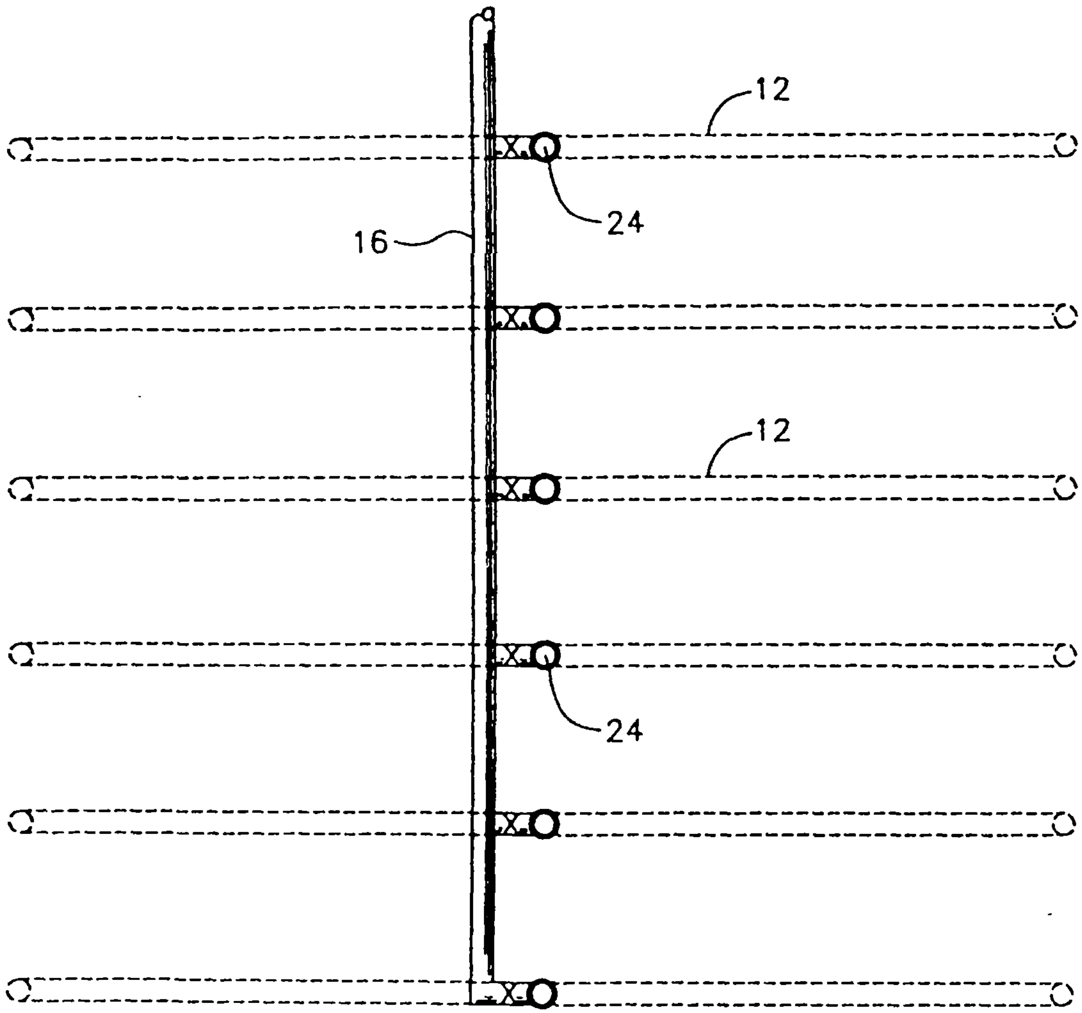
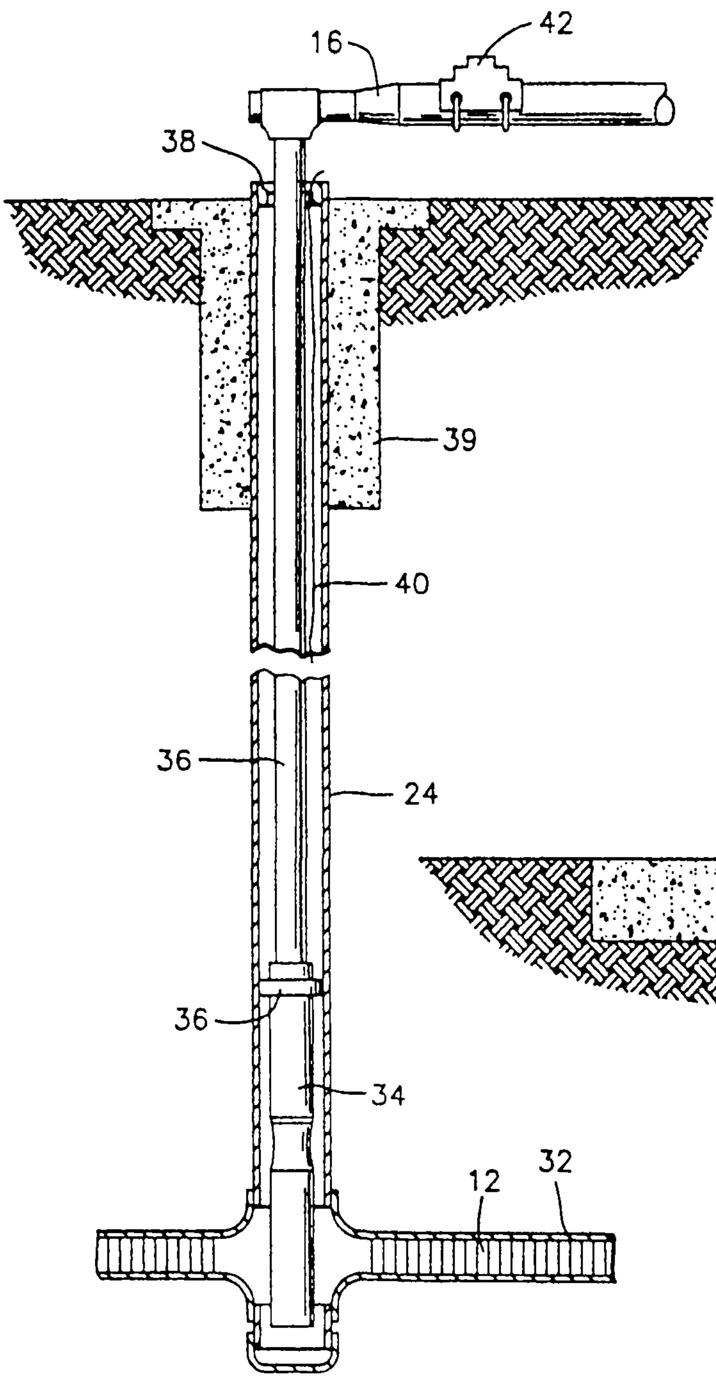


FIG. 4



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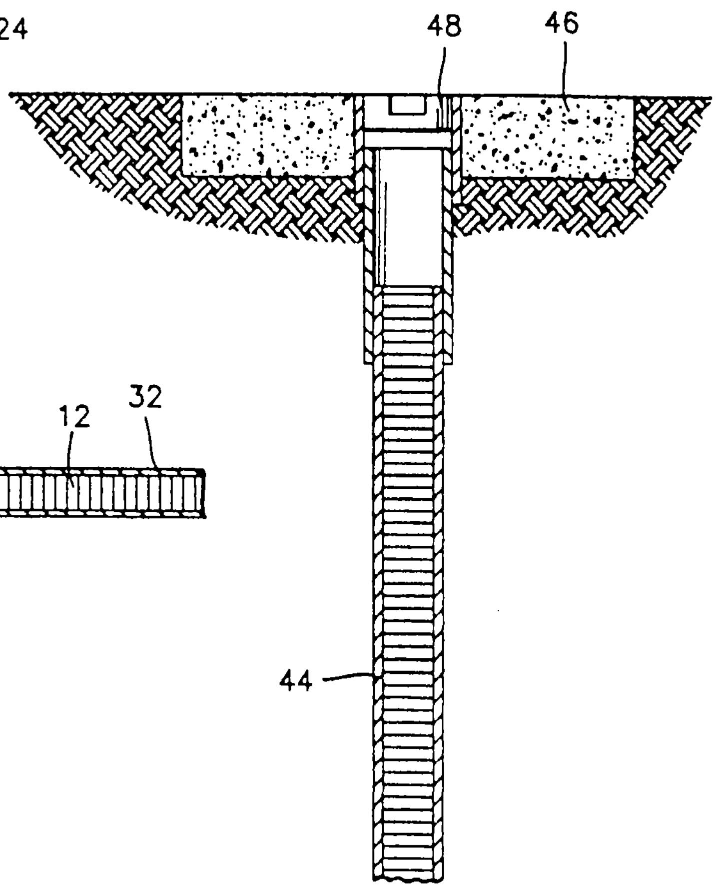


FIG. 6

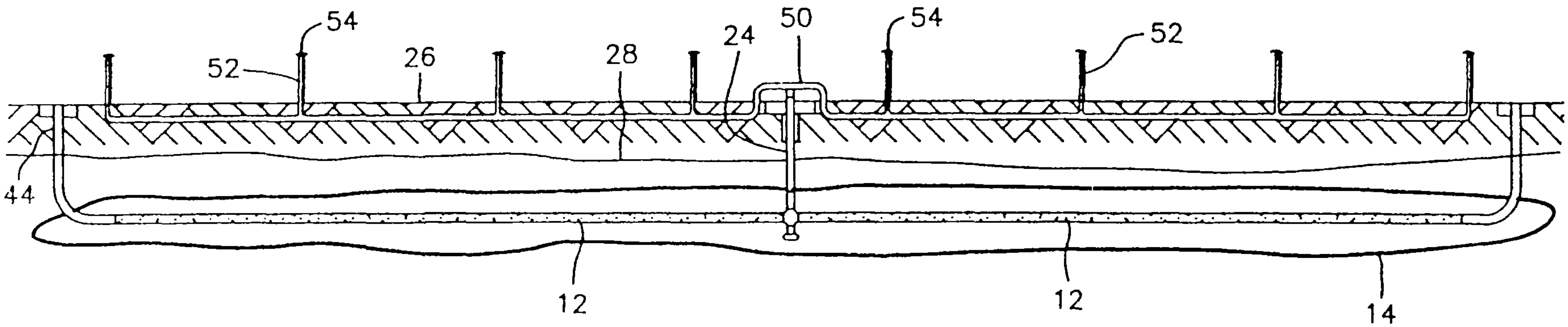


FIG. 7

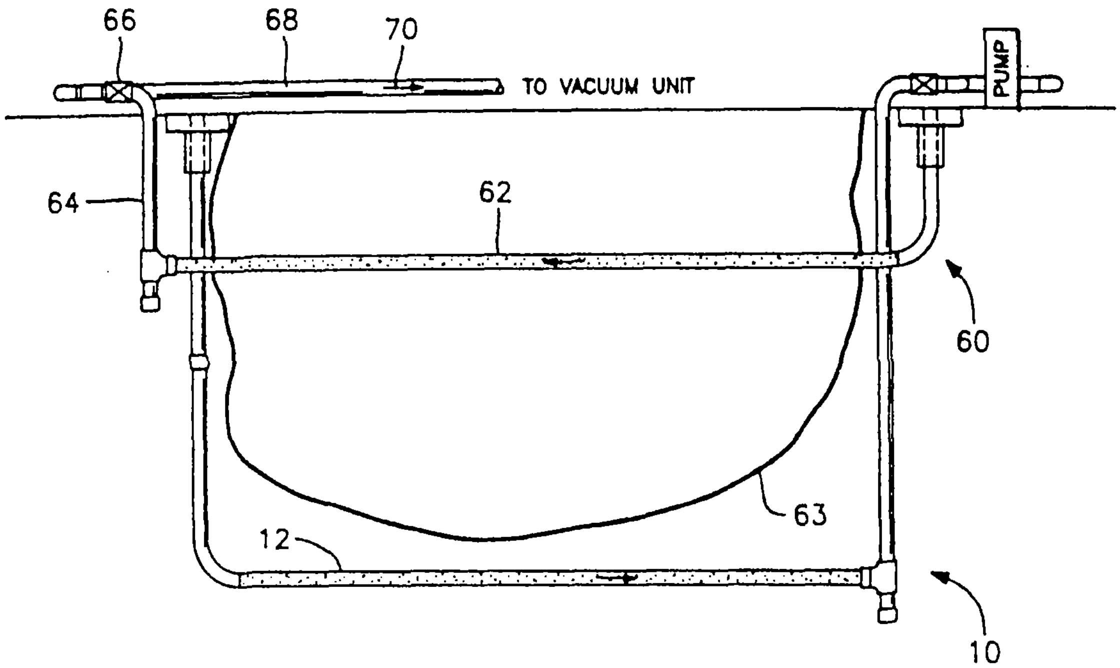
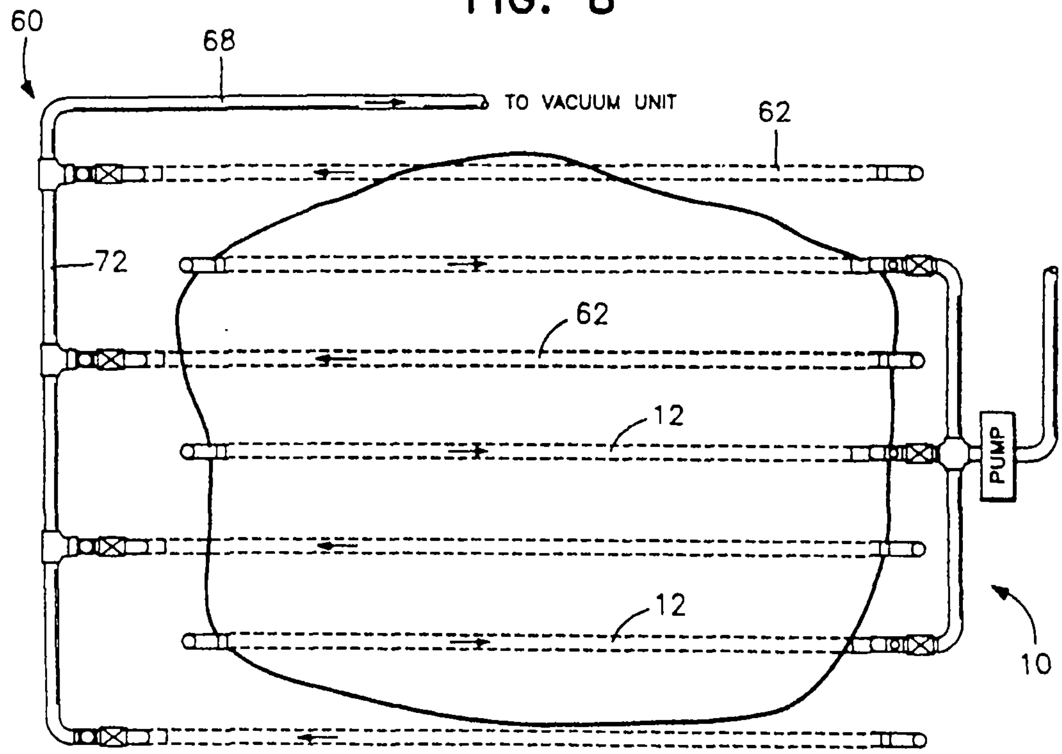

66
68
70
TO VACUUM UNIT
PUMP
64
62
60
63
12
10

FIG. 8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68
TO VACUUM UNIT
62
72
62
12
PUMP
12
10

FIG. 9

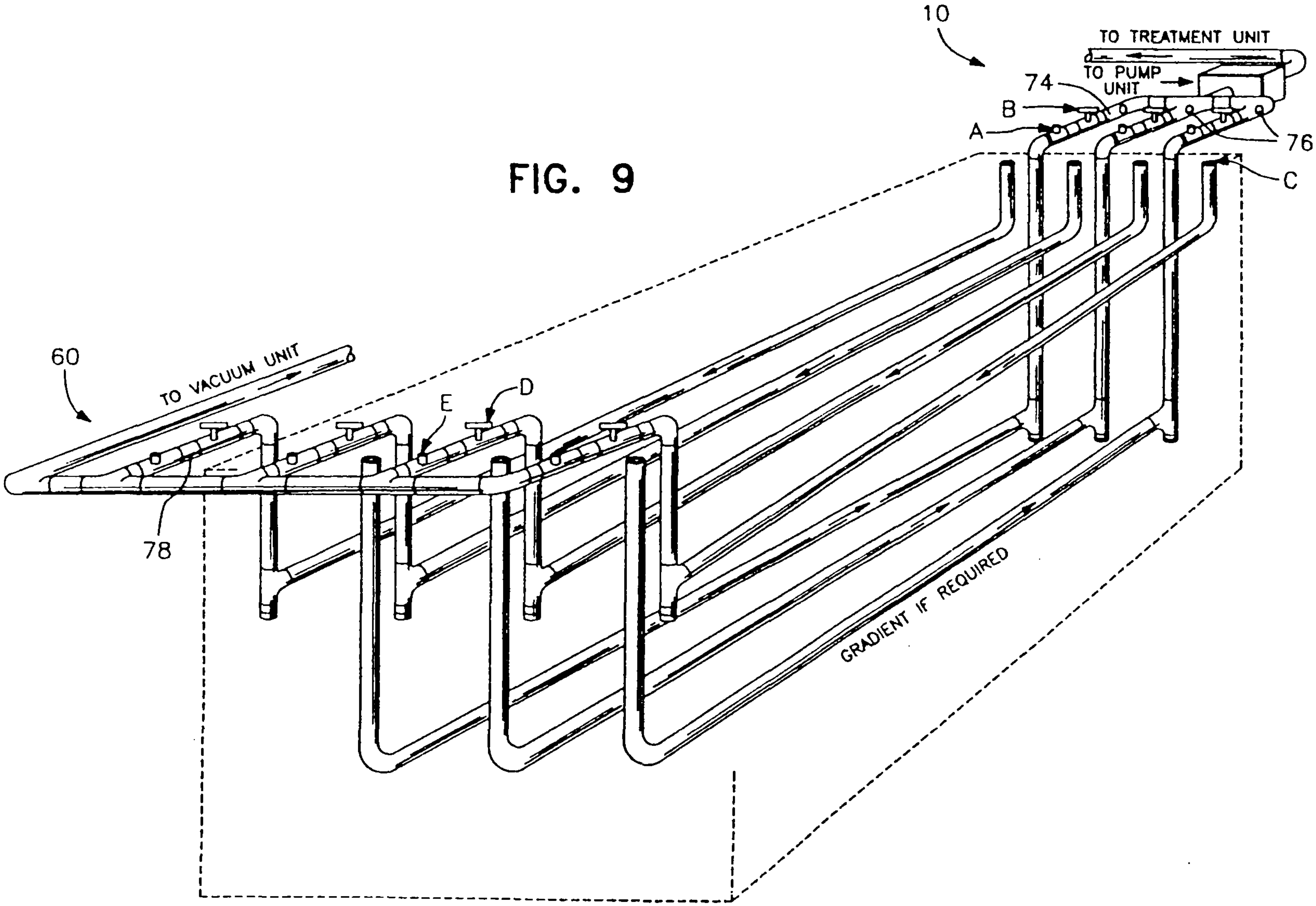
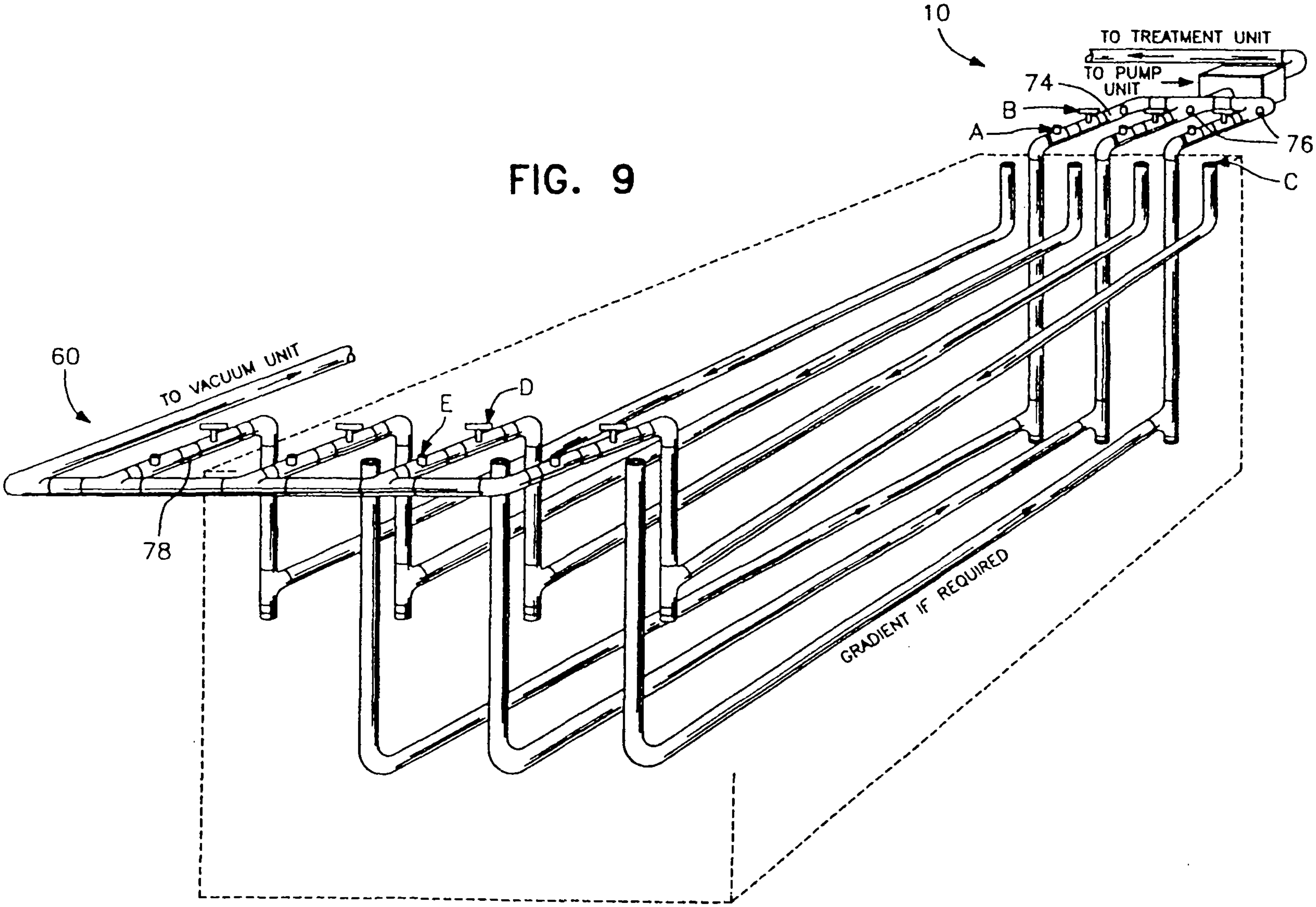

10
TO TREATMENT UNIT
TO PUMP UNIT
74
B
A
76
C
60
TO VACUUM UNIT
E
D
78
GRADIENT IF REQUIRED

FIG. 9


10
TO TREATMENT UNIT
TO PUMP UNIT
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B
A
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C
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GRADIENT IF REQUIRED

FIG. 10

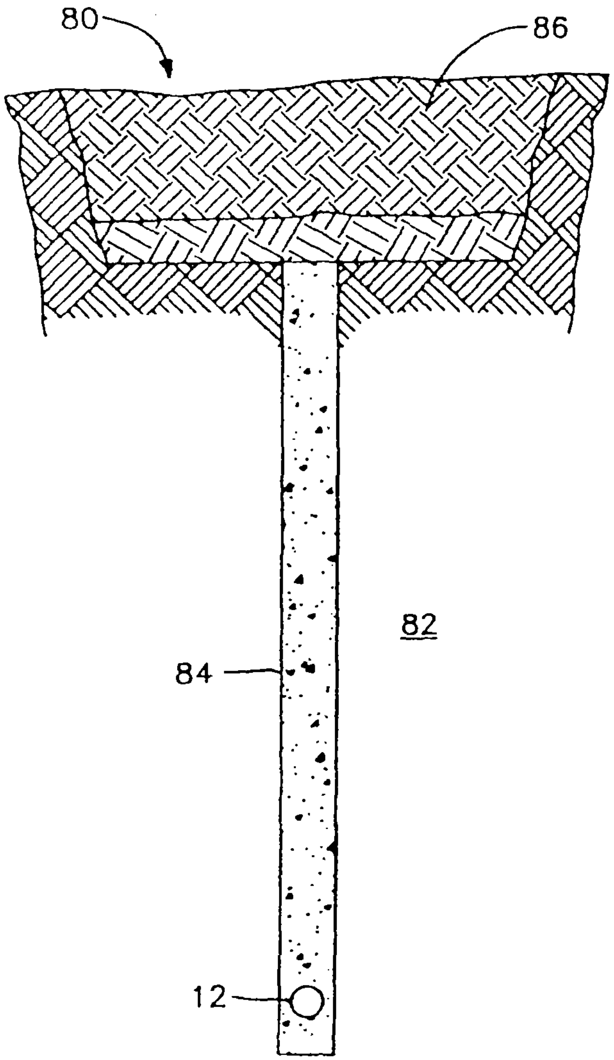


FIG. 11

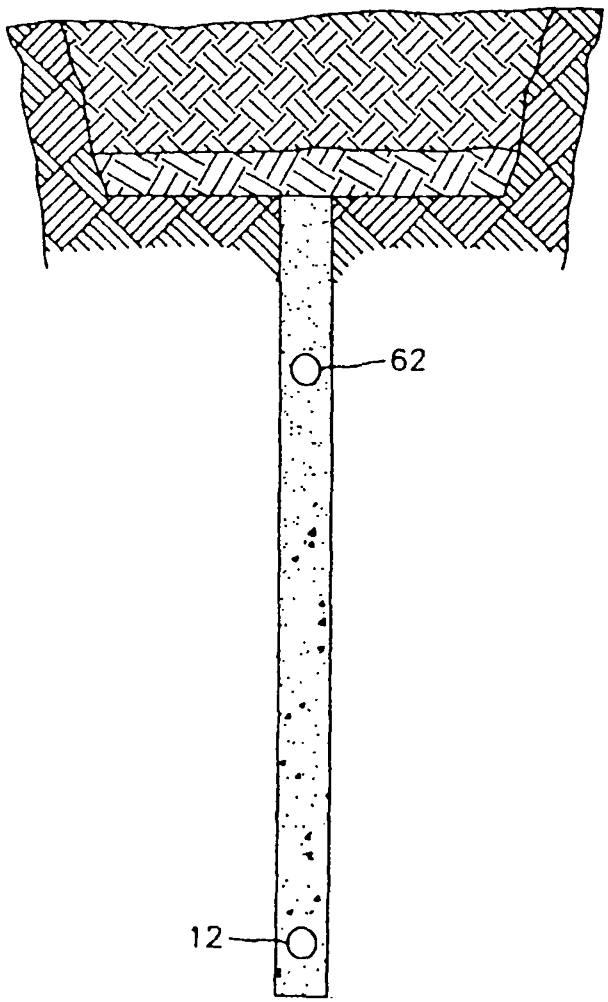
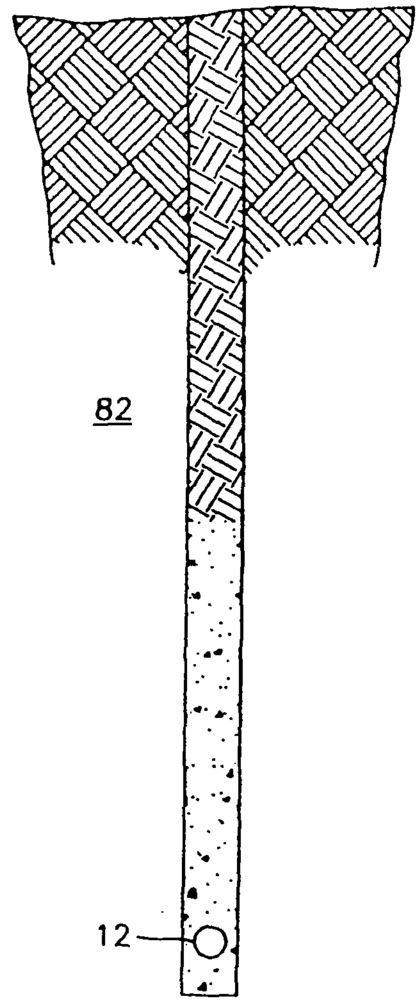


FIG. 12



LINEAR CONTAMINATE REMEDIATION SYSTEM

FIELD OF THE INVENTION

This invention is concerned with placing a horizontally extending grid system across a plume of liquid contamination contained within the water table. The grid system will remove the plume of contamination by lowering the water table and evacuating the contamination plume.

BACKGROUND OF THE INVENTION

Previous attempts to remove a plume of liquid contamination contained below ground have included placement of numerous vertical wells placed around the periphery of the plume. The vertical wells are operated continuously in an attempt to draw the liquid of a contamination plume towards the vertical well system. Great amounts of water are pumped out of the ground by these vertical wells at a great cost and over an extended period of time.

These plumes of liquid are known to contain such dangerous substances as diesel fuel, jet fuel, gasoline, heating oil, creosote, and other chemicals, for example. Sources of contamination are thousands of aging underground tanks buried beneath schools, government offices, gasoline stations, businesses and abandoned property distributed throughout the United States. This problem has often times resulted in homeowners being forced from their homes due to condemning of their homes by public officials due to the extreme hazard and health risks involved.

The presence of these contaminants in the water table present a continuous potential health hazard to the population. Rural and suburban residents who use wells for the source of their drinking water are particularly affected by this problem. It is estimated that half of the country relies on this type of source for their drinking water. The removal of these contaminants is therefore required to help ensure a potable water supply.

In 1988, the Environmental Protection Agency (EPA) issued regulations requiring that new underground tanks meet minimum standards. Owners of older tanks were forced to close or upgrade their tanks. Since these regulations have been implemented, 130,000 leaks have been documented. Experts expect hundreds of thousands of more leaks to be discovered in the future. The new EPA rules have been estimated to apply to 1.8 million tanks nationwide. This number excludes millions of home heating oil, farm and other smaller underground tanks potentially subject to producing leaks.

SUMMARY OF THE INVENTION

By the present invention a series of horizontally extending drainage recovery pipes are located at or below the level of a plume of liquid contamination. The drainage recovery pipes skim off the surface of the water table, along with the plume of contamination. This method minimizes the number of gallons of water that needs to be removed from the ground and cleaned.

Once the contaminant is pumped from the ground, it is delivered to a conventional treatment system where it is cleaned and then the cleaned water is returned back to the ground water table. This cleaned water is reintroduced over the grid system of the invention and is drawn through the soil to flush out any remaining contaminants in the soil. Once the treated water reaches the water table, the liquid contaminants are usually less dense than water and rise towards the surface of the water table. The contaminants are then removed by the grid system for treatment.

A plurality of horizontally extending drainage recovery pipes are located below the ground on 15 to 100 foot centers in or below the level of a plume of liquid contamination dependent on the volume and spread of the contamination. This depth of the horizontally extending drainage recovery pipes may vary from 8 to 30 feet below ground level and is dependent upon the variable height of the water table.

The horizontally extending drainage pipes are used in cleanup efforts on contaminated sites, both for contaminated water and contaminate extraction. Aquifer recharge is obtained by using treated and/or processed water which is returned to the water table. The horizontally extending drainage recovery pipes are laid in a series of parallel trenches at or below the level of the plume of contamination. The trenches are dug by specialized equipment as described in my U.S. Pat. No. 4,871,281, hereby incorporated by reference.

It is not required that personnel work in the excavated trenches for placement of the recovery pipes, thus reducing exposure to contaminants and other safety hazards. Also, the recovery pipes are locatable at the desired pumping points, even in saturated soils. This minimizes the need for off-site handling and disposal of contaminated free product and water which is extremely costly and hazardous.

The drainage recovery pipe, including a filter casing, is placed along with filter sand in the trench and the trench is back-filled with the same soil removed to dig the trench. By the burial of the horizontally extended drainage recovery pipe at or below the site of contamination, ground water removal is minimized while containment recovery is maximized to thereby reduce waste water treatment volume and operational costs. As the water table is lowered, the plume of liquid contamination is lowered into direct contact with the drainage recovery pipes.

By utilization of a soil benching installation method, the need to handle contaminated soils from the excavations, disposal, either on site or off-site, is minimized or eliminated. The project costs and hazardous exposure to personnel is thereby reduced.

In the soil benching installation method, non-contaminated surface soils are excavated to depths of 3-6 feet and stored on site. The installation equipment is operated in the excavated or benched area to excavate contaminated soil. The excavated contaminated soils are deposited along the trench line in the bottom of the trenched area. After the recovery pipe installation is completed, the stored on-site, non-contaminated surface soils are replaced in and over the benched area.

The grid system incorporating the horizontally extending drainage recovery pipe includes a plurality of lengths of pipe extending 600 linear feet. The pipe is preferably six inch diameter high density polyethylene encased by a filter cloth. A central eight inch diameter PVC riser is located in the middle of each length of drainage pipe. At a location above ground, each of the vertical risers are interconnected by a suction header which transfers withdrawn water and contamination to a processing facility.

The horizontal extending pipes have a clean-out/air relief vertically rising section at the outer ends of each

600 foot length of pipe. Therefore, there are two clean-out/air relief sections for each horizontal length of pipe. Access is thereby facilitated at both ends and a mid-point of the drainage recovery pipe for removal of contaminated liquid.

It is possible to remove the upper level of the ground water table along with the harmful contamination plume by pumping out a plurality of horizontally extending drainage recovery pipes over a 24 hour period one time a week, for example. The actual pumping time will vary according to the extent of contamination and the proximity of the recovery pipes to the plume of contamination.

All of the liquid removed is passed through a carbon filter system and is ultimately treated for removal of contaminants. The filtered liquid may be returned to the ground above the horizontal pipe drainage recovery system so that the liquid passes through the soil to the water table in a soil washing system which assists in the removal of contamination from contaminated soil. This is equivalent to a "site dialysis" which is used to continuously circulate liquid to flush contaminant from the water supply. The level of contamination is thereby significantly reduced to an acceptable level.

This system can also be utilized as a vapor extraction process, either independently or in conjunction with a free product/water recovery system. Upper vapor recovery piping can be utilized as recharge points of treated water at an area directly over a contaminated plume area, thereby enhancing soils flushing and the area cleanup process. Additional air can be induced into the lower free product and water recovery pipes which allows enhancement of vaporization of the plume contaminants and vapor recovery by the upper system.

Flow recovery rates of free product and water recovery are adjustable from time to time with balancing valves from individual recovery runs to minimize the circulation in the recovery/treatment cycle of low contaminated waters. This maximizes the recovery and treatment of higher contaminated waters.

The site specific grid systems of the invention can include a perimeter recovery system around the plume. This can not only be utilized in the recovery treatment process, but can also serve as a plume containment installation.

It is therefore an object of the present invention to provide a method of removing a plume of liquid contamination by reducing the level of the water table and thereby collect and remove the plume of liquid contamination.

It is another object of the present invention to provide a method of removing a plume of liquid contamination by reducing the level of the water table and thereby collect and remove the plume of liquid contamination with a plurality of horizontally extending drainage recovery pipes located at or below the level of the plume of contamination.

It is still another object of the present invention to provide a method of removing a plume of liquid contamination by reducing the level of the water table and thereby collect and remove the plume of liquid contamination with a plurality of horizontally extending drainage recovery pipes located at or below the level of the plume of contamination with the horizontally extending drainage recovery pipes having a vertical riser for removal of contaminated liquid and passage of the contaminated liquid to a filter system.

It is still another of the present invention to provide a method of removing a plume of liquid contamination by reducing the level of the water table and thereby collect and remove the plume of liquid contamination with a plurality of horizontally extending drainage recovery pipes located at or below the level of the plume of contamination with the horizontally extending drainage recovery pipes having a vertical riser for removal of contaminated liquid and passage of the contaminated liquid to a filter system with the contaminated liquid being filtered and returned to the site of the horizontally extending drainage recovery pipes for passage through the soil above the drainage recovery pipes so as to flush contaminants from the soil and towards the drainage recovery pipes.

These and other objects of the invention, as well as many of the intended advantages thereof, will become more readily apparent when reference is made to the following description taken in conjunction with the accompanying drawings.

BRIEF DESCRIPTION OF THE DRAWINGS

FIG. 1 is a top plan view of a contamination site having a plume of liquid contamination with a linear contaminated waste recovery system in place.

FIG. 2 is a sectional view of a linear contaminated waste recovery system in place having a horizontally extending drainage recovery pipe located below a plume of liquid contamination.

FIG. 3 is a plan view of a linear contaminated waste recovery system.

FIG. 4 is a partial sectional view of a horizontal well vertical header and riser.

FIG. 5 is a partial sectional view of a horizontal well flexible riser clean-out.

FIG. 6 is a sectional view of a linear contaminated waste recovery system with filtered liquid flushing system.

FIG. 7 is a sectional view of a linear contaminated waste recovery system and vapor recovery system.

FIG. 8 is a top plan view of the systems shown in FIG. 7.

FIG. 9 is a perspective view of the systems shown in FIGS. 7 and 8.

FIGS. 10 through 12 illustrate various trenching operations.

DETAILED DESCRIPTION OF THE PREFERRED EMBODIMENTS

In describing a preferred embodiment of the invention illustrated in the drawings, specific terminology will be resorted to for the sake in clarity. However, the invention is not intended to be limited to the specific terms so selected, and it is to be understood that each specific term includes all technical equivalents which operate in a similar manner to accomplish a similar purpose.

With reference to the drawings, in general, and to FIG. 1 in particular, a linear contaminated waste recovery system embodying the teachings of the subject invention is generally designated as 10. The containment system includes a plurality of buried horizontally extending drainage recovery pipes or horizontal well screen 12 which are located at or below the level of a buried plume of contaminated liquid 14.

In this example, a former public works building 16 has, over the years, leaked fuel contaminant into the ground. These contaminants have collected and are a potential danger to the water supply. By burying the recovery pipes 12 below or at the level the plume 14 of liquid contamination, the water table is thereby lowered and the plume 14 is lowered into direct contact with the drainage recovery pipes 12 for evacuation from the water table.

The recovery pipes 12 are connected to a suction header 16 which is above ground level. The suction header 16 is connected to the recovery pipes by a vertical riser 24 as shown in FIGS. 2, 4 and 5. The riser may actually rise vertically at an angle of from 30° to 90° dependent on the location of the pump, above or below ground, and the desired pumping volume.

The suction header is connected by a transfer pipe 18 to an above ground pumping unit 20. It is not necessary that the pumping unit be located above ground, but rather the pumping unit may be of a below ground type as depicted in my U.S. Pat. No. 4,927,292, hereby incorporated by reference.

A discharge pipe 22 is connected to the pumping unit to convey the liquid withdrawn by the recovery pipes to a treatment facility. It is possible, as will be explained with reference to FIG. 6 to return the treated liquid to the ground above the recovery pipes so as to use the treated liquid to help flush out the soil above the recovery pipes for evacuation of any remaining contaminants from the soil for treatment at a treatment facility.

In FIG. 2, a recovery pipe 12 is shown connected to a vertical riser 24 which extends to above ground level 26 for removal of liquid below the upper surface 28 of the water table. The plume 14 of contaminated liquid is shown being located near the upper surface 28 of the water table. Typically, the contaminated liquid will be of a density less than water and will float to the upper surface of the water table. As the water table is lowered by water entering recovery pipes 12 and evacuation of the contaminated liquid through vertical riser 24, the level of the upper surface 28 of the water table and the plume 14 itself, will be lowered as moved in the direction of arrows 30 and evacuated by the recovery pipe 12.

Typically, a plurality of rows of recovery pipes 12, as shown in FIG. 3, will be connected to their respective vertical risers 24 for connection to a suction header 16 and ultimate removal of contaminated liquid to a waste treatment facility. In the example shown, the recovery pipes extend for a distance of 600 feet and are spaced at 100 feet centers. The separation of the recovery pipes will depend upon the volume and the extent of spread of the plume 14 of contaminated liquid.

In FIG. 4, the details of recovery of contaminated liquid from corrugated recovery pipe 12 are shown. The recovery pipe 12 surrounded by a filter cloth 32 is connected to an eight inch PVC vertical riser 24. Within the header 24 is a submersible pumping unit 34 having a surrounding seal 36. The pumping unit 34 is connected to a 3-inch discharge pipe 36 and passes through a well head seal 38 in concrete seal 39 for connection with a suction header 16. Electric leads 40 pass through the well head seal to the pumping unit for energizing the pumping unit. The suction header 16 is a 4-inch discharge pipe having a water meter 42 for measuring the amount of contaminated liquid extracted.

At the opposite end of the recovery pipe 12 from the vertical header 24 is a flexible riser 44 as shown in FIGS. 2 and 5. The flexible riser terminates at a concrete seal 46 having a six-inch counter sunk plug 48 for access to the riser 44 and clean-out of the riser in the event the recovery pipe becomes clogged.

In a preferred embodiment as shown in FIG. 6, recovery pipe 12 is located within plume 14 of contaminated liquid near the upper surface 28 of the water table. As the contaminated liquid of the plume 14 is gathered in the recovery pipes 12, it is pumped from the vertical riser 24 and ultimately to a waste treatment facility.

The treated liquid is returned by return pipe 50 and spread over the soil by a plurality of vertical irrigation poles 52. Irrigation poles 52 include a sprinkler head 54 for distribution of the treated liquid over the soil. The treated liquid passing through the soil acts to flush the soil and move any contaminants that may be contained in the soil towards the recovery pipes 12 and its surrounding plume 14 of contaminated liquid. This "site dialysis" forces contaminants out of the soil and aids in removing the contaminants from the water table. This process is repeated until the level of contamination of the soil is reduced and of the plume 14 of contaminated liquid is removed.

Flushing of the soil and removal of the plume is accomplished in a greatly reduced time period involving a substantially reduced amount of liquid to be treated. Therefore, once a site of liquid contamination is located, the horizontally extending recovery pipes 12 are located in place to draw down the water table and thereby encounter the plume of contaminated liquid to remove the plume.

In FIGS. 7 through 9, a vapor recovery or extraction system 60 is shown used in combination with a linear contaminated waste recovery system 10. System 60 includes a plurality to lengths of horizontally extending perforated pipe 62 spaced at a distance above the drainage recovery pipe 12 of system 10. Pipe 62 is positioned within the soil 63 above the water table.

Pipe 62 is connected to a vertical riser 64 which is connected at a point 66 to an evacuation tube 68 for withdrawing air in the direction of arrow 70 as caused by a vacuum unit. Gases rising from the plume of contaminated liquid are forced into pipe 62 and removed from a site of contamination.

In FIG. 8, the inter-lineation of pipes 62 of system 60 and pipes 12 of system 10 are shown. In FIG. 8, a header 72 is shown to which the plurality of pipes 64 are connected for evacuation through evacuation tube 68. Pipes 62 may also be used for a return of treated fluid to a site of a plume as described with respect to FIG. 6 so as to rinse the soil and carry contaminants towards the recovery system 10 located adjacent to a plume of contaminated liquid.

In FIG. 9, additional details of the systems 10 and 60 are shown. Each drainage recovery pipe 12 includes in a section of pipe 64 a flow meter A for measuring the rate of flow of product from recovery pipes 12 as controlled by an equalizing valve B. Dependent upon samples removed from a sampling port 76, it is determined to what extent contaminated product is being removed from a recovery site. If it is determined that a low level of contamination is being removed from a particular recovery pipe, its equalizing valve is varied to reduce the rate of flow as measured by flow meter A so as to reduce the amount of water being drawn from the water table through a particular recovery pipe. Conversely, in the recovery pipes 12 measuring a high degree of contaminant in the product removed from the recovery pipe, the equalizing valve is opened to increase the rate of flow of product and thereby increase the amount of contaminant removed.

In the vapor recovery system 60, a length of pipe 78 includes an equalizing valve D and a manometer tap port E for each pipe section 62. Similar to recovery system 10, dependent upon the amount of gas removed by each pipe section 62, the amount of suction exerted on a particular pipe is varied by the turning of equalizing valve D as measured at the manometer tap port E.

In FIGS. 10 and 11, a benched area 80 of non-contaminated soil is removed over a 12-14 foot width to a depth dependent on a soil contamination survey to access non-contaminated soil. After initiating removal of the benched area, a trenching operation is performed through contaminated soil 82 at a width of approximately 14 inches within which recovery pipe 12 is buried by back-filling contaminated soil within the trench 84. The non-contaminated soil 86 is then returned into the benched area 80 to seal the contaminated soil and prevent exposure of contamination to the trenching personnel..

In FIG. 11, a similar operation is performed with burial of a vapor recovery pipe 62. This is contrasted to the trenching of non-contaminated soil as shown in FIG. 12 for burial of any recovery pipe 12.

Having described the invention, many modifications thereto will become apparent to those skilled in the art to which it pertains without deviation from the spirit of the invention as defined by the scope of the appended claims.

I claim:

1. A method for removing a plume of contaminated liquid from the earth, said method comprising:
  - locating a plume of contaminated liquid,
  - positioning a plurality of rows of parallel, horizontally extending perforated recovery pipes at a depth substantially at or below the depth to which the plume of contaminated liquid extends,
  - removing water from the water table to move the plume of contaminated liquid into contact with the recovery pipes,
  - removing the plume of contaminated liquid from below ground level by passage through the horizontally extending recovery pipes as the plume moves into the horizontally extending recovery pipes,
  - positioning a vapor recovery system above the recovery pipes and below ground level to recover vapors generated by the plume including substantially horizontal pipes with open perforations.

2. A method according to claim 1, wherein said recovery pipes are positioned below the plume of contaminated liquid.

3. A method according to claim 1, wherein a pumping unit forces liquid entering the recovery pipes to an above ground location.

4. A method according to claim 3, wherein a treatment facility treats water entered into the recovery pipes.

5. A method according to claim 4, wherein the treatment facility is located above ground level.

6. A method according to claim 4, wherein the plume occupies a site and water treated by the treatment facility is returned to the site of the plume of contaminated liquid for release above the site of the plume of contaminated liquid so as to pass through the soil towards the site of the plume of contaminated liquid.

7. A method according to claim 6, wherein water treated by the treatment facility, after passing through the soil, is removed by the recovery pipes for a second treatment at the treatment facility.

8. A method according to claim 1, wherein the recovery pipes are positioned to extend across the plume of contaminated liquid.

9. A method according to claim 1, wherein a volume of flow through the recovery pipes is varied dependent upon the degree of contamination passing through each recovery pipe.

10. A method for removing a plume of contaminated liquid from the earth, said system comprising:
  - burying a plurality of horizontally extending perforated recovery pipes at a depth substantially at or below the depth to which the plume of contaminated liquid extends,
  - positioning a vapor recovery system above the recovery pipes and below ground level to recover vapors generated by the plume including substantially horizontal pipes with open perforations,
  - pumping liquid entering the recovery pipes to an above ground location, and
  - treating the liquid pumped to the above ground location to remove contaminants.

11. A method according to claim 10, wherein the recovery pipes are buried below the plume of contaminated liquid.

12. A method according to claim 10, wherein the plume occupies a site and the treated liquid is returned to the site of the buried recovery pipes and released above the buried recovery pipes so that the treated liquid passes through the soil towards the buried recovery pipes.

13. A method according to claim 12, wherein the treated liquid, after passing through the soil, is removed by the recovery pipes for a second treatment to remove contaminants.

14. A method according to claim 10, wherein the buried recovery pipes extend parallel to each other.

15. A method according to claim 10, wherein the plume of contaminated liquid is located adjacent to an upper surface of the water table and the plume of contaminated level is lowered vertically across the buried recovery pipes to move the plume of contaminated liquid into contact with the recovery pipes.

16. Method according to claim 10, wherein a volume of flow through the recovery pipes is varied dependent upon the degree of contamination passing through each recovery pipe.

17. A method for removing a plume of contaminants from the earth, said method comprising:
  - locating a plume of contaminants,
  - positioning a plurality of rows of parallel, horizontally extending perforated recovery pipes at a depth substantially at or below the depth to which the plume of contaminants extends, and
  - positioning a vapor recovery system above the recovery pipes and below ground level to recover vapors generated by the plume including substantially horizontal pipes with open perforations.

* * * * *

TECHNICAL SPECIFICATIONS
FOR
HORIZONTAL WELLS
AND
LINEAR CONTAMINANT REMEDIATION SYSTEMS

I. Material Specifications

1. High Density Polyethylene Horizontal Well

The physical properties of polyethylene resin in corrugated tubing manufactured in compliance with the AASHTO M 252 "Corrugated Polyethylene Drainage Tubing" and ASTM F 405 "Corrugated Polyethylene (PE) Tubing and Fittings" general material specifications must comply with the requirements of ASTM D 1248 "Polyethylene Plastics Molding and Extrusion Materials". Based upon the ASTM D 1248 standard, polyethylene resins used in the manufacture of corrugated tubing are classified as Type III (high density), Category 4 or 5, Class C (weather-resistant containing not less than 2% carbon black) resins with tensile, brittleness temperature, and environmental stress crack resistance properties in compliance with one of the following resin pipe grades:

- ASTM 405. Grades P14, P23, P33 and P34

- AASHTO M 252. Grades P33 and P34

High density polyethylene resins are, for all practical purposes, chemically inert, although the Grade P34 resin is the most chemically resistant. Natural soil and groundwater chemicals, therefore, will not affect the long-term properties or behavior of corrugated drainage tubing. Further, because polyethylene is not an electrical conductor, the resin does not rust or corrode by electrolytic or galvanic action. Polyethylene is also non-biodegradable and does not support the growth of nor is it affected by bacteria.

Test Lab Results on Compliance:

A. Perforated Tubing. The perforated tubing is in compliance with AASHTO M 252 and ASTM F 405 specifications with the exception of the maximum slot width slightly exceeding the AASHTO M 252 requirement of a maximum slot of 0.125 inches. Because the perforated pipe is installed with a filter fabric sock, the slightly wider slot width should not be significant. Gram weight 420 per lineal foot.

B. Solid Tubing. The solid tubing is in compliance with AASHTO M 252 specifications except for the inside diameter occasionally being slightly less (by 0.001 inches) than the allowable minimum of 4.925 inches, which is not significant and the somewhat nonuniform coloring (i.e., the orange coloring contained black streaks along the length of the tubing). The solid tubing is in compliance with ASTM F 405 specifications except for the somewhat nonuniform color. Gram weight 600 per lineal foot.

2. Filter Fabric Encasement

The L.C.R.S. utilizes a double encasement of synthetic drain sock material.

Material: Knitted Polyester (100%)

Fiber Length: Continuous

Color: White

6" Highway Grade

Fabric Weight - Ounces per Square Yard (ASTM D231-62)
Relaxed 5.5, Applied 3.5

Yarn Size: 200 Denier

Burst Strength: (P.S.I. - ASTM D231) 125

Air Permeability - CFM Per Square Foot (ASTM D737-69) 500

(Other filter encasement materials are available on special order)

3. Pumping Risers and Appurtenant Process Piping

Pipe and Related Fitting - Schedule 40 or 80 P.V.C.

Schedule 40 - Material Specifications ASTM D-1784

Dimension Specifications - ASTM D-1785

Schedule 80 - Material Specifications - ASTM D-1784

Dimension Specifications ASTM D-1785

3. Continued

Schedule 40 fittings shall conform to ASTM D-2466.

Schedule 80 fittings shall conform to ASTM D-2467 for socket fittings and ASTM D-2464 for threaded fittings.

4. Special Coupling Adapters

The special coupling adapters shall conform in size and shape to fit the corrugated HDPE pipe as specified.

They shall be manufactured of materials which will allow solvent welded and/or mechanically coupled joints to connect to the receiving PVC or other piping material.

Further, they shall comply with the design and intent of U.S. Patent No. 5,072,972 dated 12-17-91.

5. Valves and Specialty Items

A. All valves shall be of material specification to be compatible with the intended application, inclusive of but not limited to Ball Valves, Butterfly Valves, Gate Valves, Globe Valves, Plug Valves or Cocks, Check Valves (Swing Gate, Ball, Spring Loaded) and others.

B. All gauges, pressure sensors, pressure switches, level controls (probes or floats) shall be of pressure rating, material construction and application compatible to the site specific project.

6. Meters

All metering points shall include the installation of flow meters that are designed to provide accurate flow rates and total flows of their specific application. In some cases, reversible flow meters may be desired.

Further, if system automation is desired, the meter can be expanded in design to include a remote reading point of flow rate and total flow.

4

Comparative Solute Transport Simulations of Horizontal and Vertical Well Remediation Systems

One Horizontal Well

10 Feet Deep, 500 Feet Long

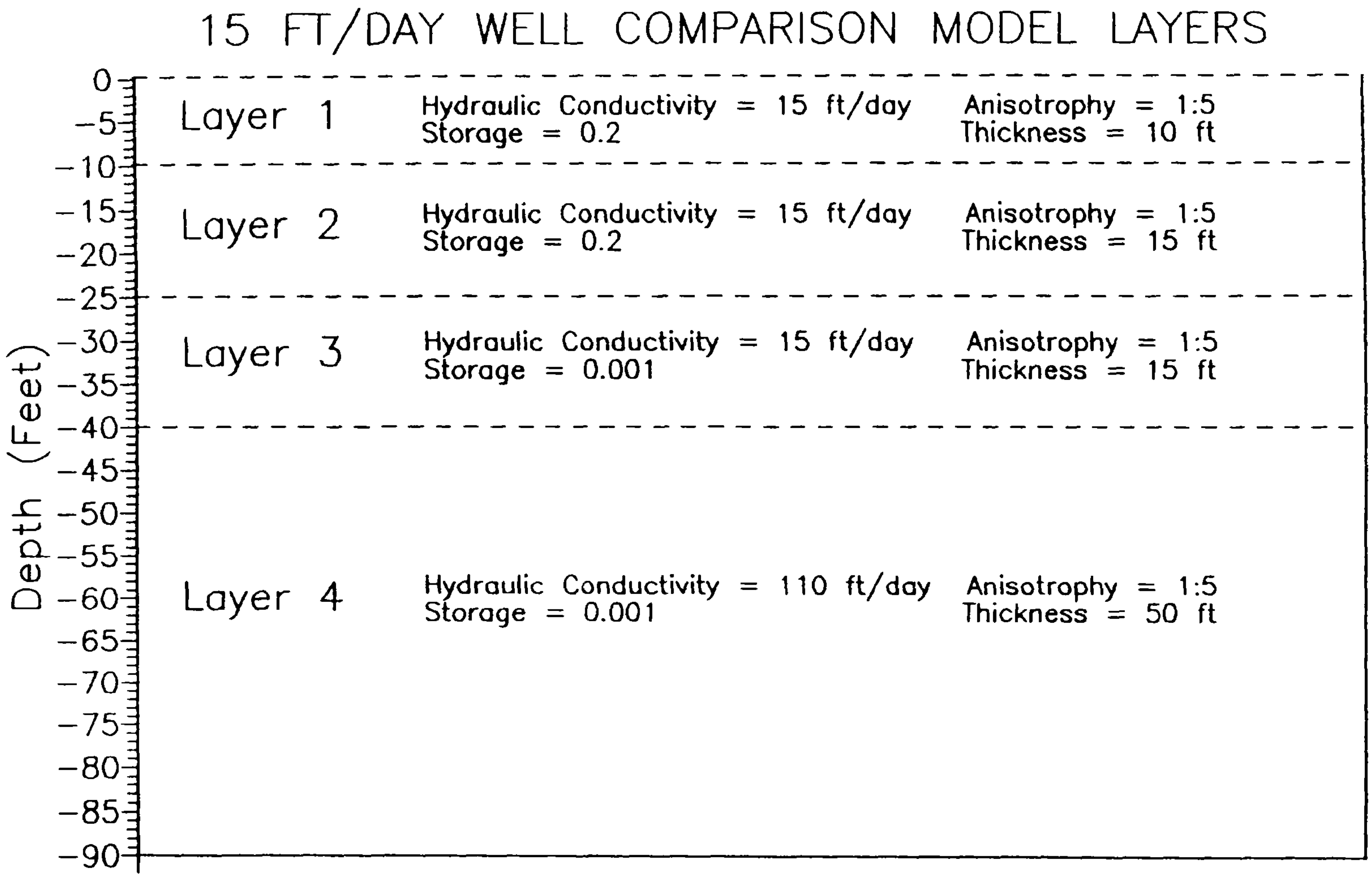
Pumping 75 GPM

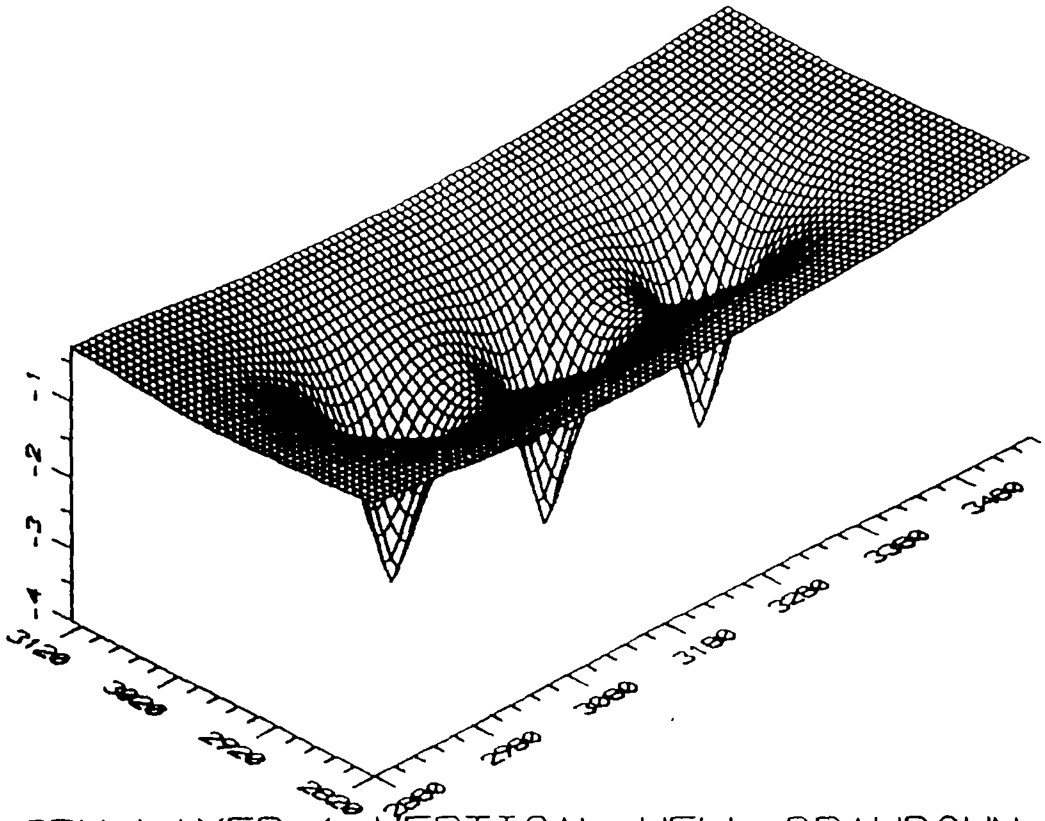
vs

Three 25 Feet Deep Vertical Wells

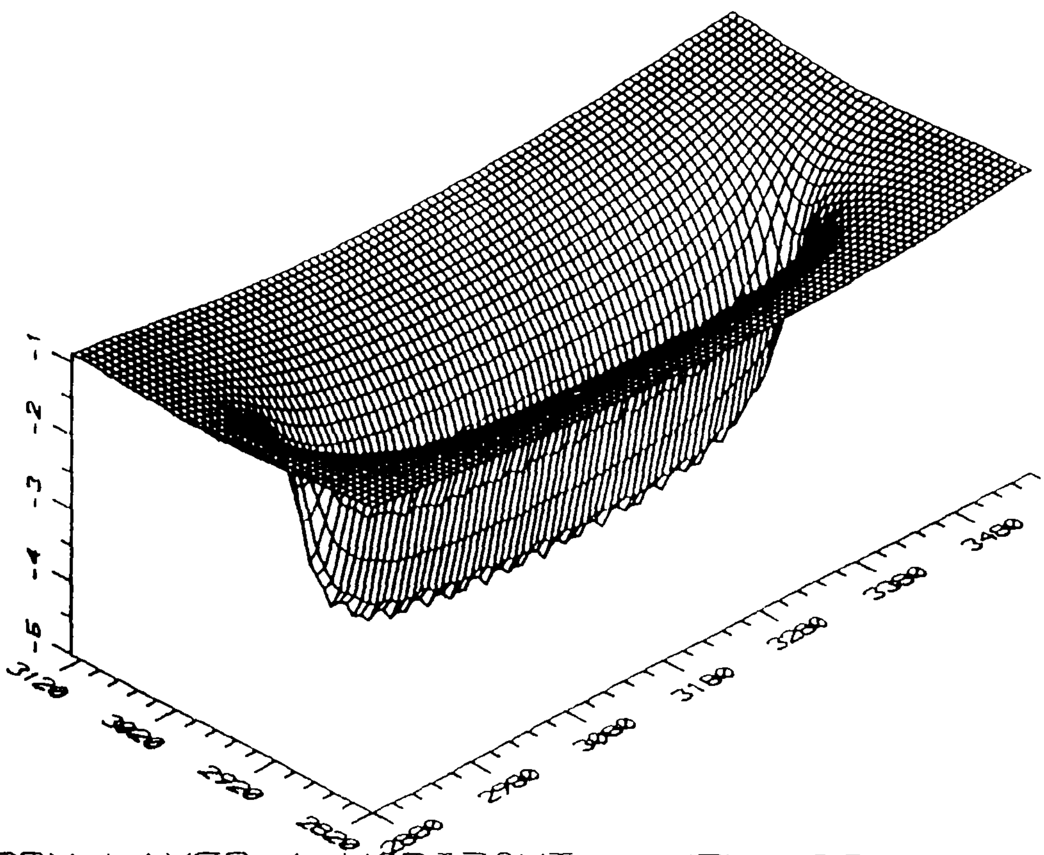
Optimally Spaced 165 Feet Apart

Pumping 25 GPM Each


15 FT/DAY WELL COMPARISON MODEL LAYERS
Depth (Feet)
0
-5
-10
-15
-20
-25
-30
-35
-40
-45
-50
-55
-60
-65
-70
-75
-80
-85
-90
Layer 1
Hydraulic Conductivity = 15 ft/day
Storage = 0.2
Anisotrophy = 1:5
Thickness = 10 ft
Layer 2
Hydraulic Conductivity = 15 ft/day
Storage = 0.2
Anisotrophy = 1:5
Thickness = 15 ft
Layer 3
Hydraulic Conductivity = 15 ft/day
Storage = 0.001
Anisotrophy = 1:5
Thickness = 15 ft
Layer 4
Hydraulic Conductivity = 110 ft/day
Storage = 0.001
Anisotrophy = 1:5
Thickness = 50 ft

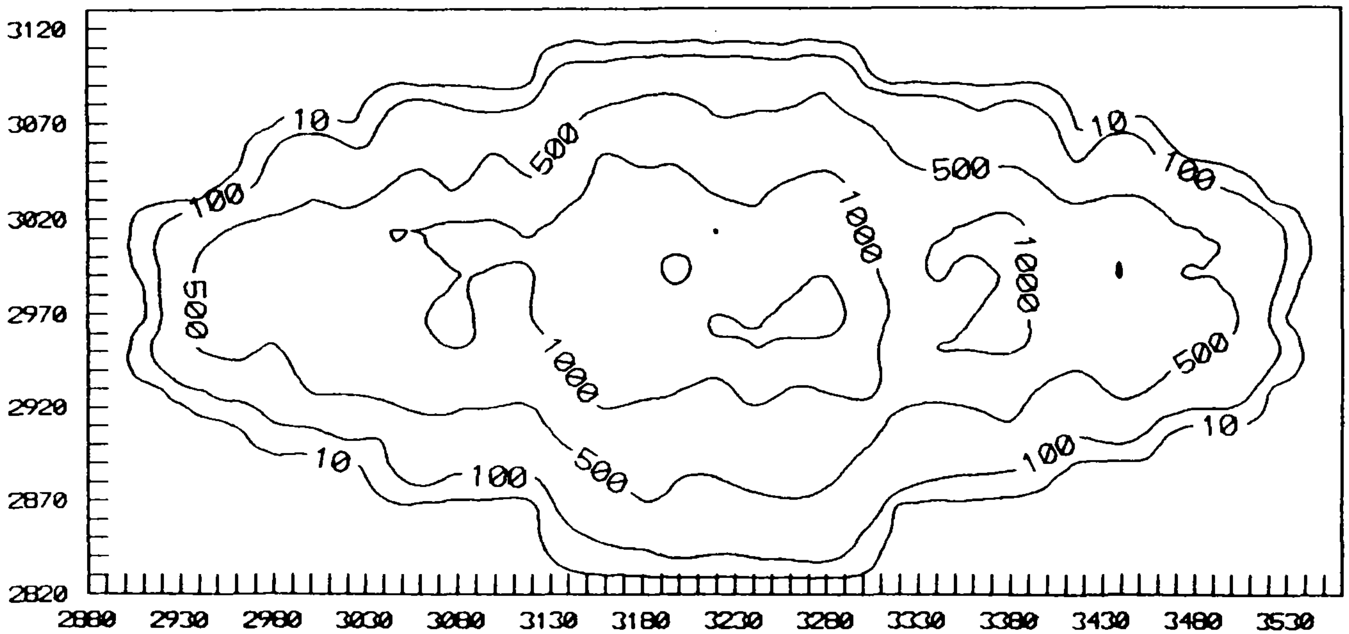


75 GPM LAYER 1 VERTICAL WELL DRAWDOWN PLOT

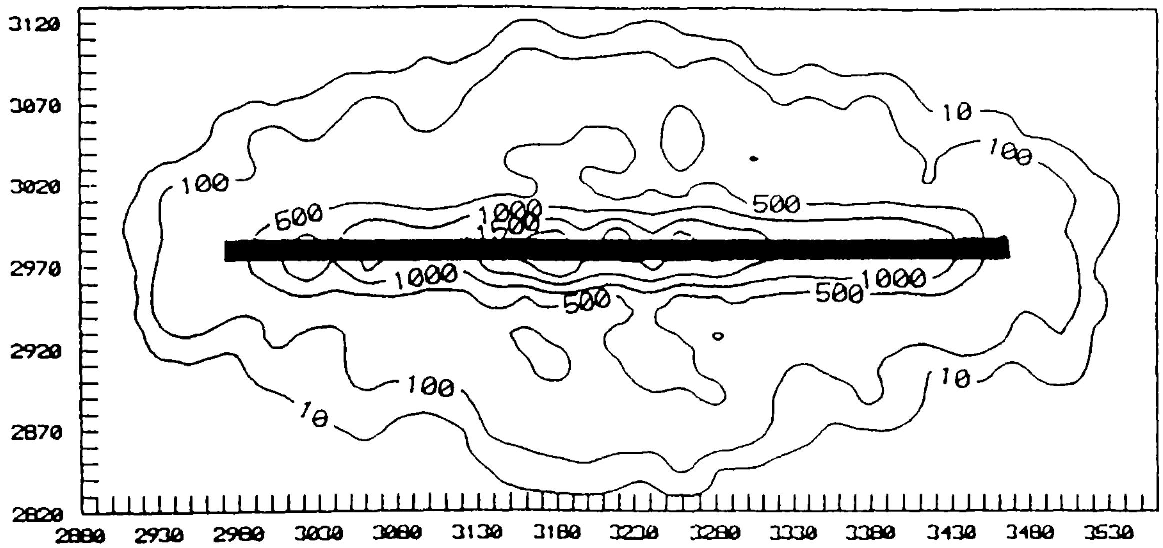


75 GPM LAYER 1 HORIZONTAL WELL DRAWDOWN PLOT

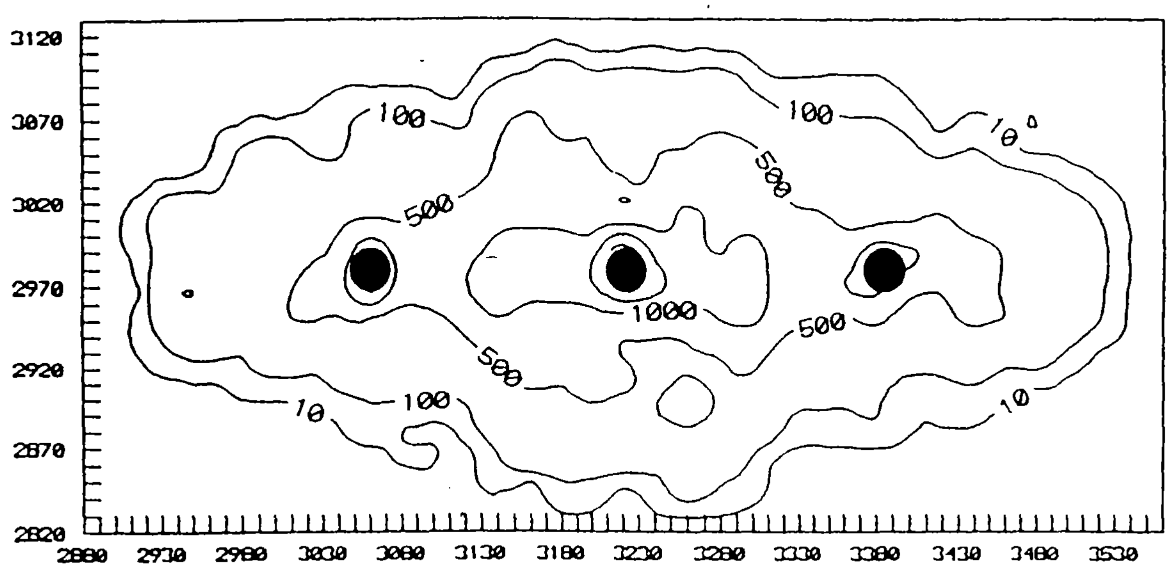
LAYER 1 INITIAL PLUME CONCENTRATION (ug/l)



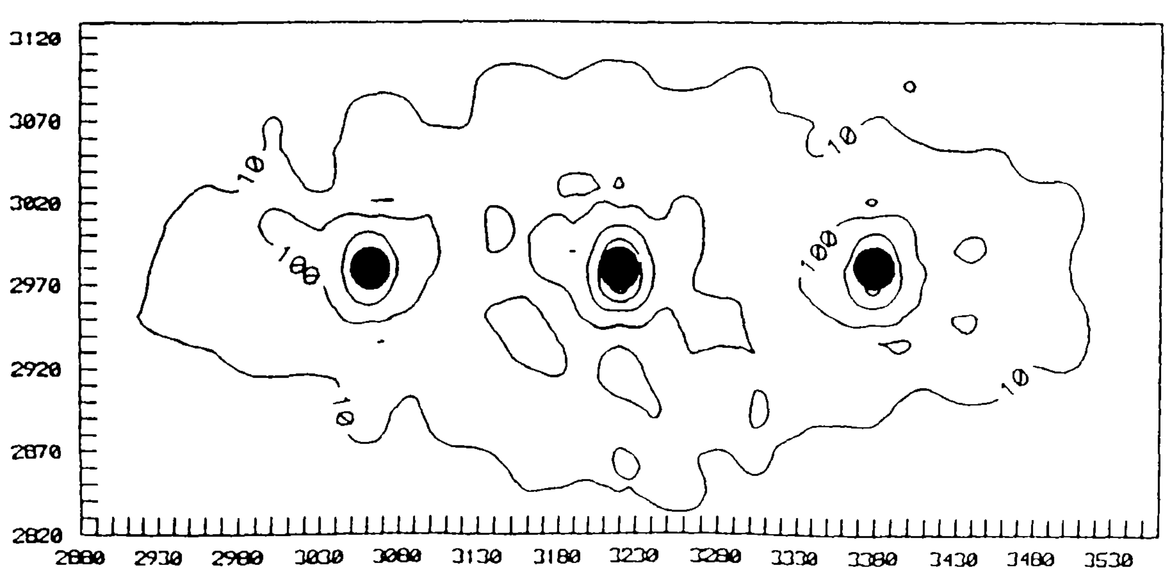
DAY 20 HORIZ. WELL LAYER 1 CONCENTRATION (ug/l)



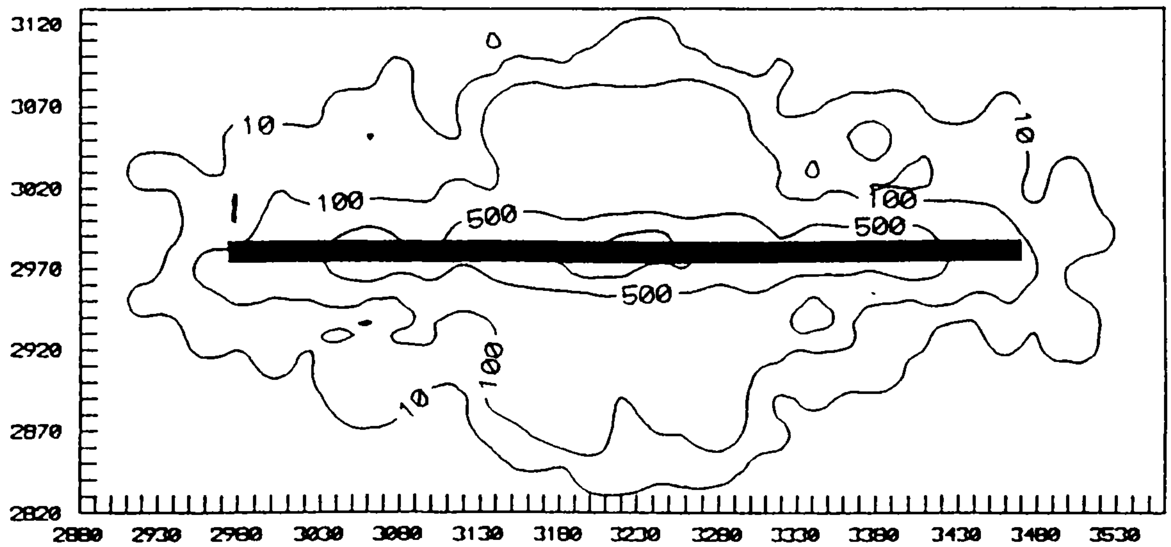
DAY 20 VERT. WELL LAYER 1 CONCENTRATION (ug/l)



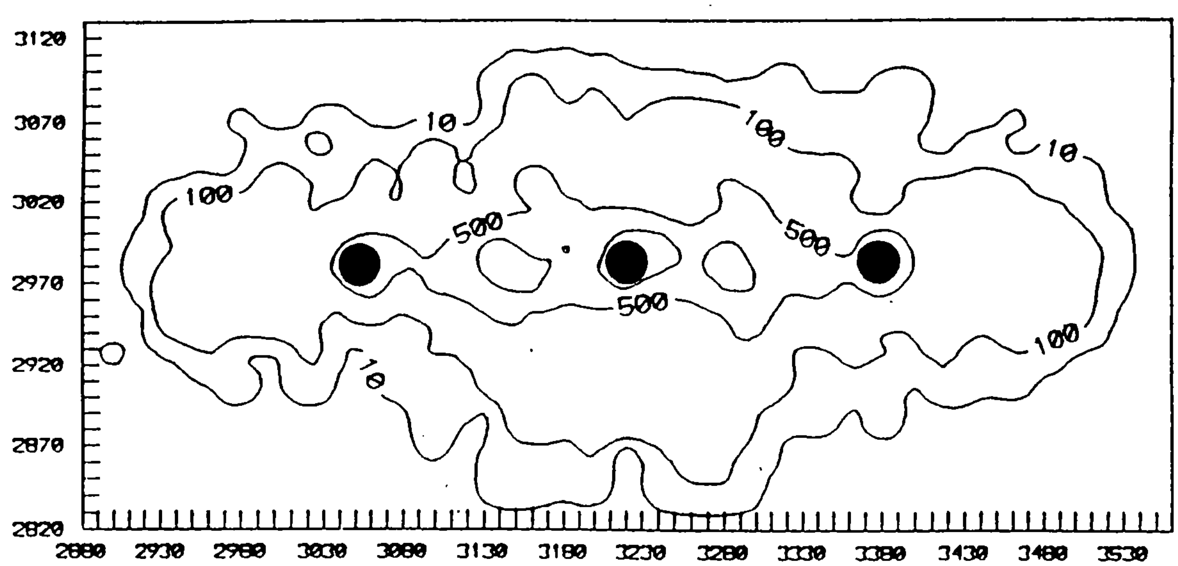
DAY 20 VERT. WELL LAYER 2 CONCENTRATION (ug/l)



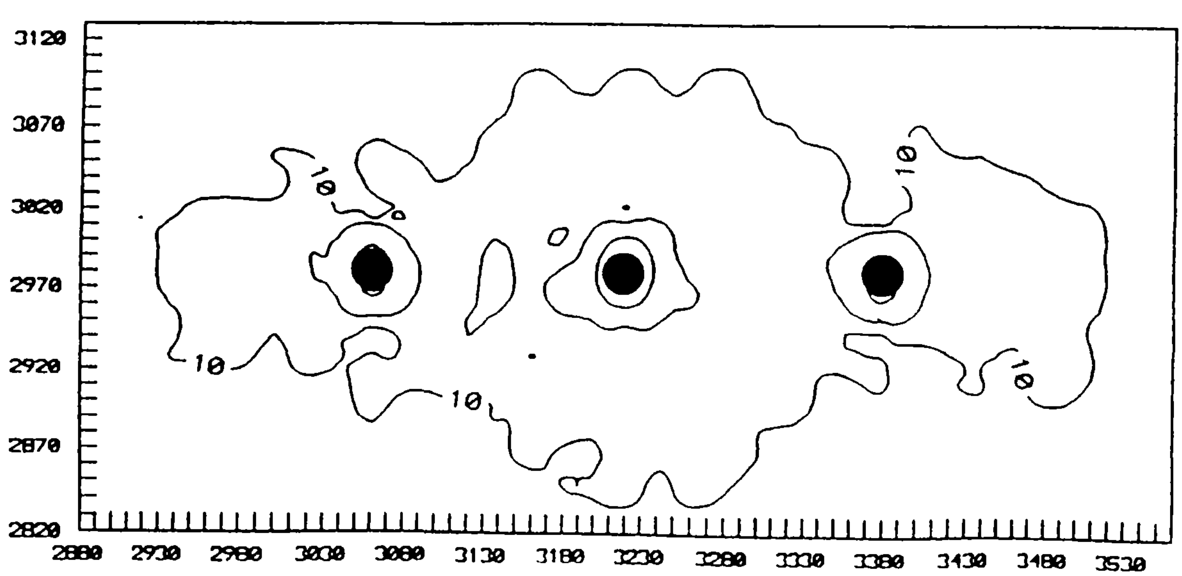
DAY 48 HORIZ. WELL LAYER 1 CONCENTRATION (ug/l)



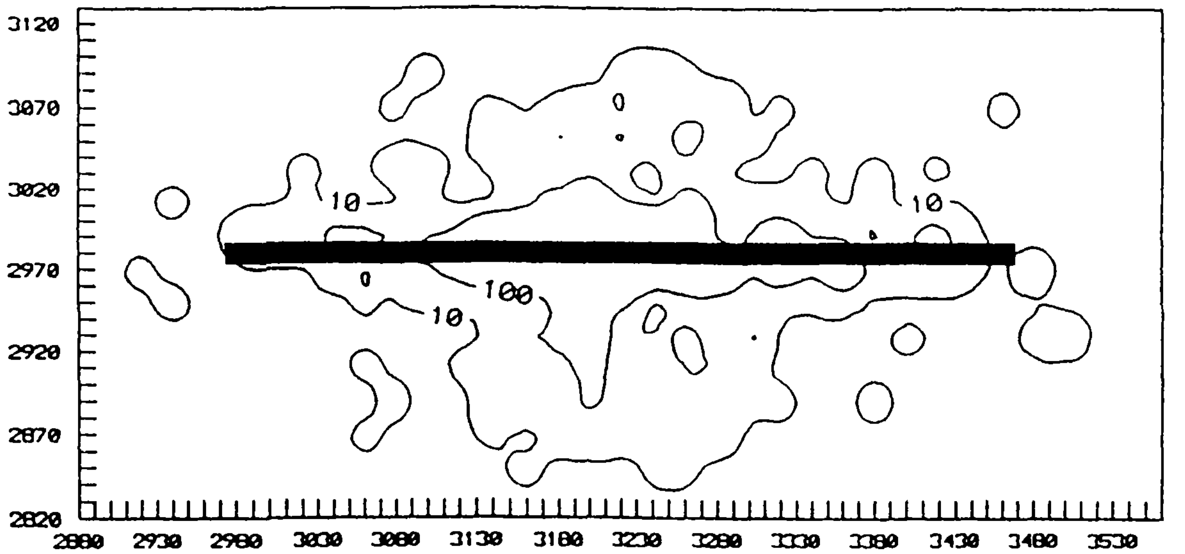
DAY 48 VERT. WELL LAYER 1 CONCENTRATION (ug/l)



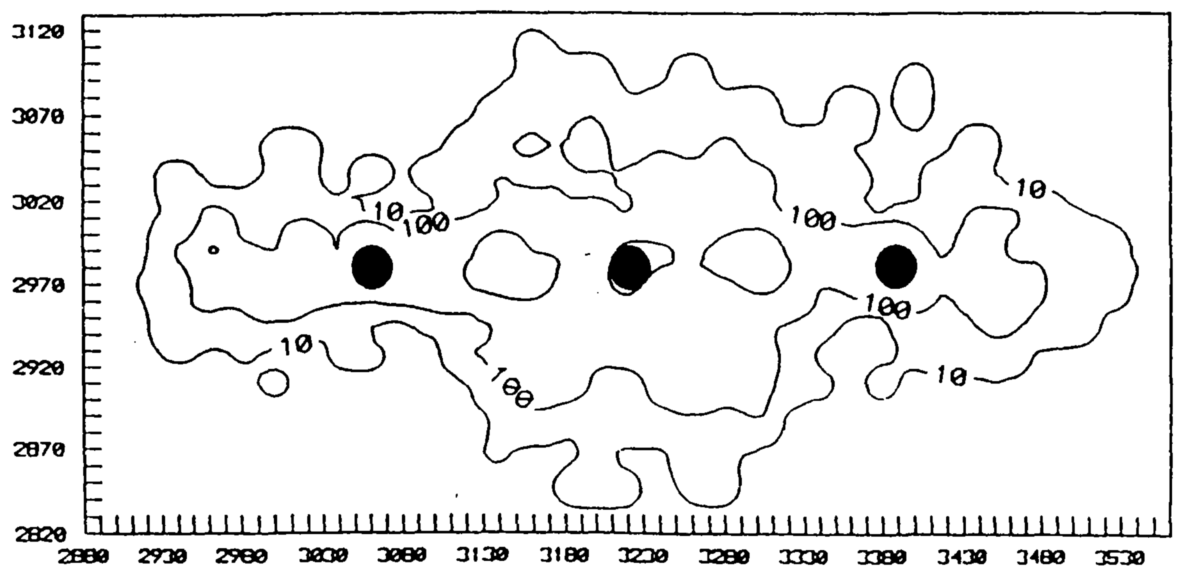
DAY 48 VERT. WELL LAYER 2 CONCENTRATION (ug/l)



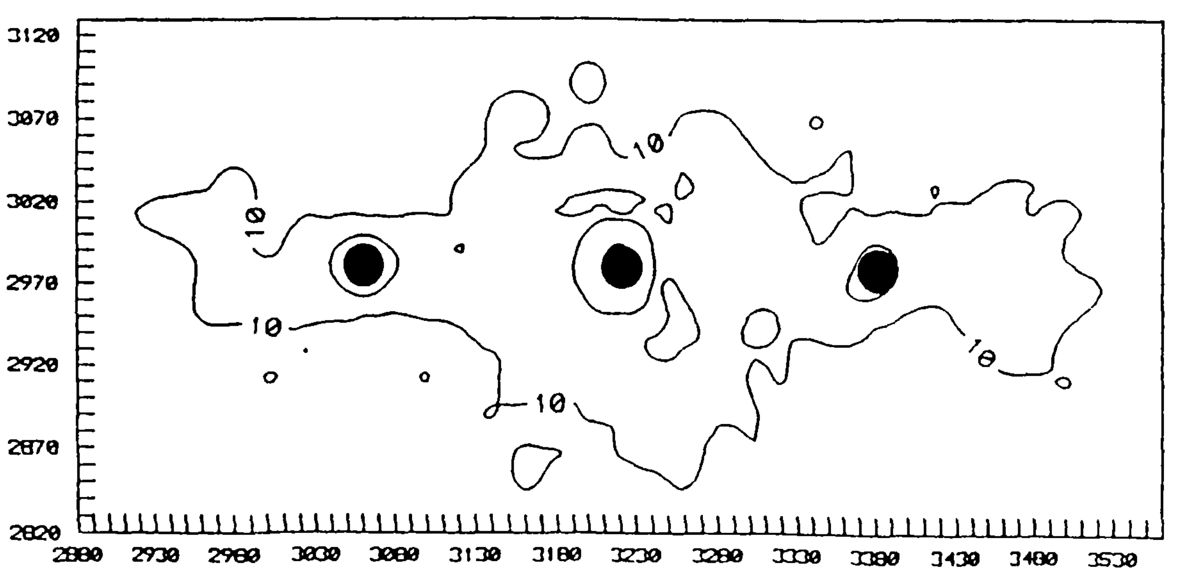
DAY 96 HORIZ. WELL LAYER 1 CONCENTRATION (ug/l)



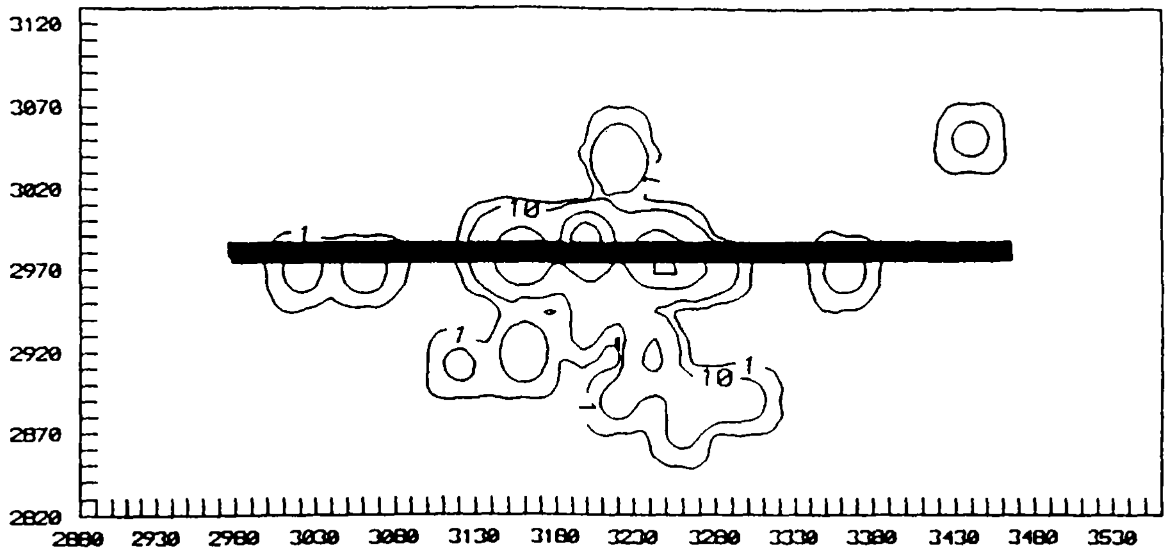
DAY 96 VERT. WELL LAYER 1 CONCENTRATION (ug/l)



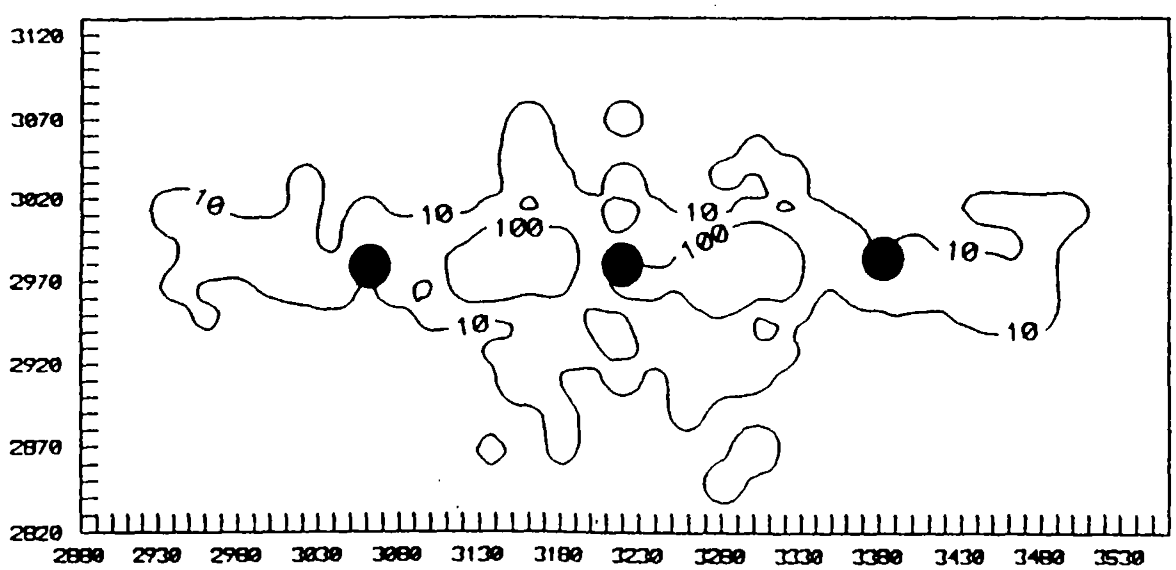
DAY 96 VERT. WELL LAYER 2 CONCENTRATION (ug/l)



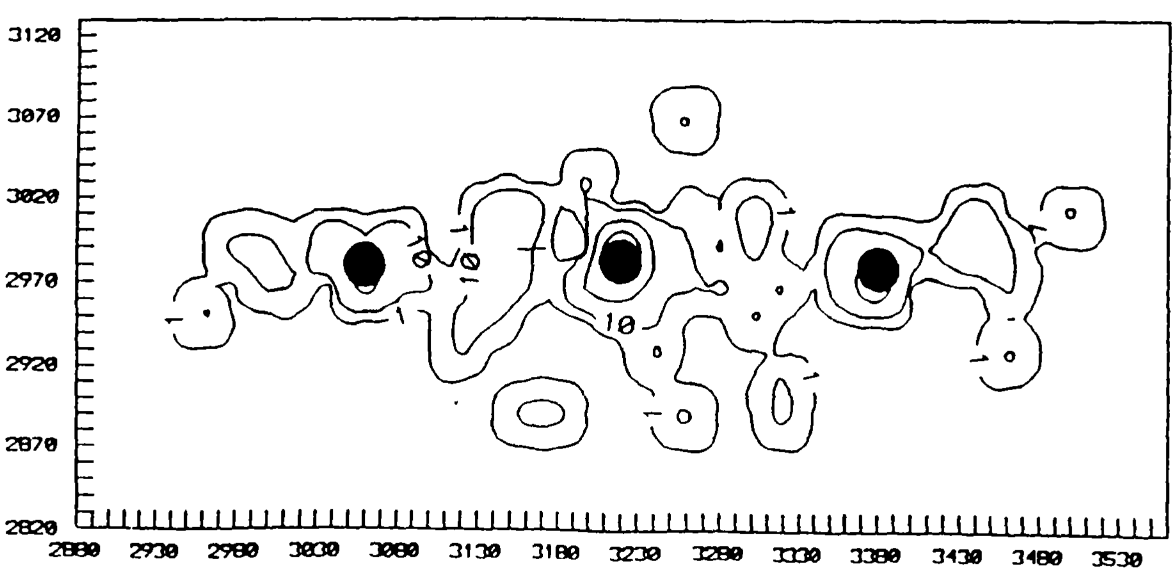
DAY 180 HORIZ. WELL LAYER 1 CONCENTRATION (ug/l)



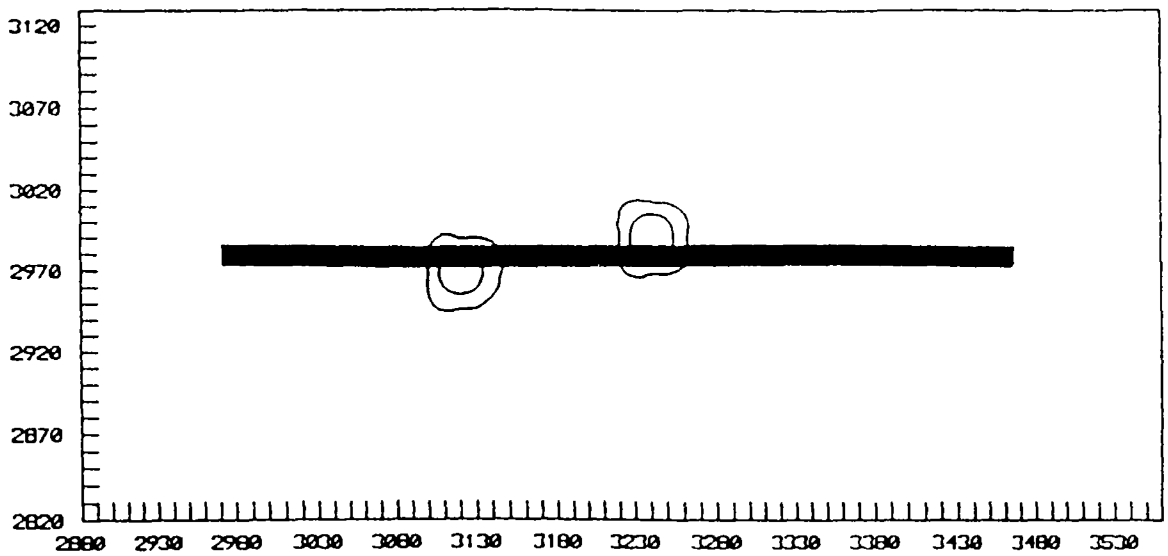
DAY 180 VERT. WELL LAYER 1 CONCENTRATION (ug/l)



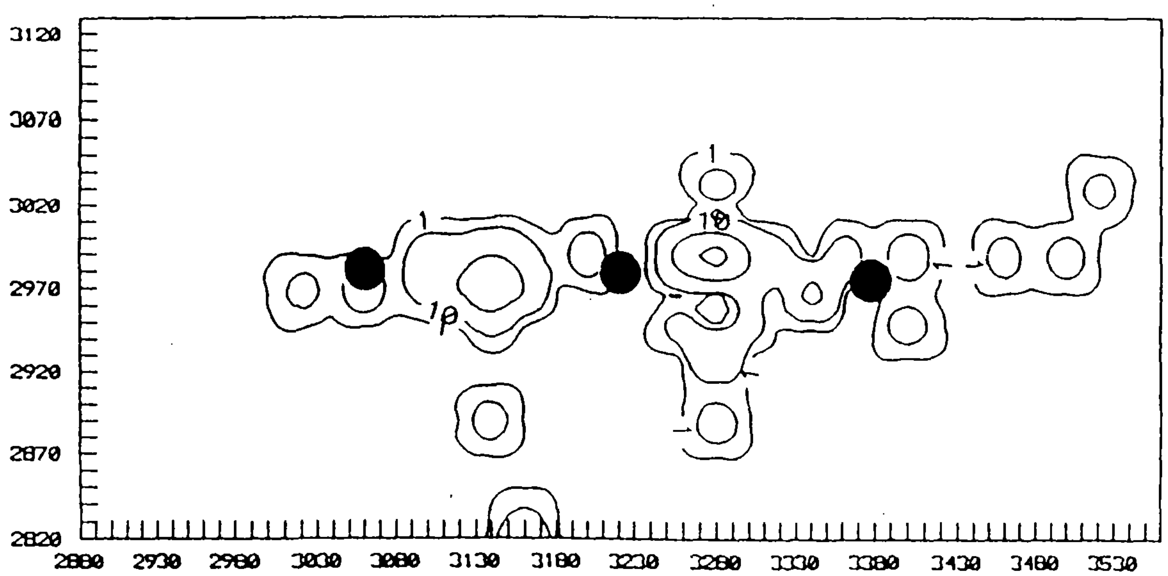
DAY 180 VERT. WELL LAYER 2 CONCENTRATION (ug/l)



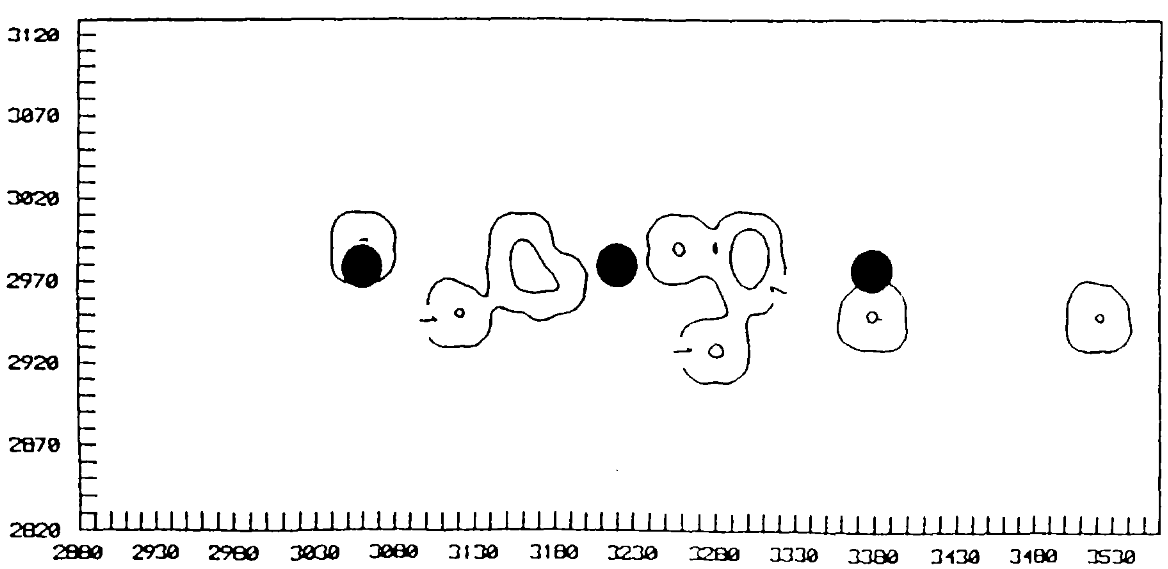
DAY 276 HORIZ. WELL LAYER 1 CONCENTRATION (ug/l)



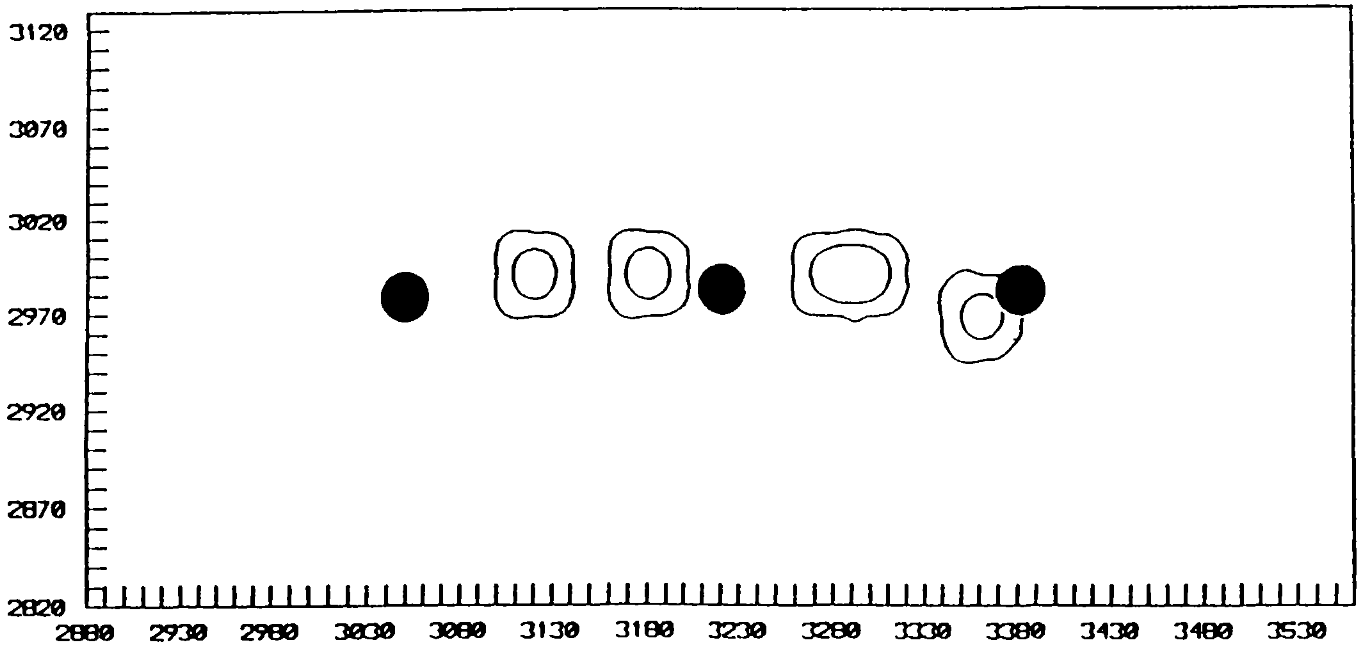
DAY 276 VERT. WELL LAYER 1 CONCENTRATION (ug/l)



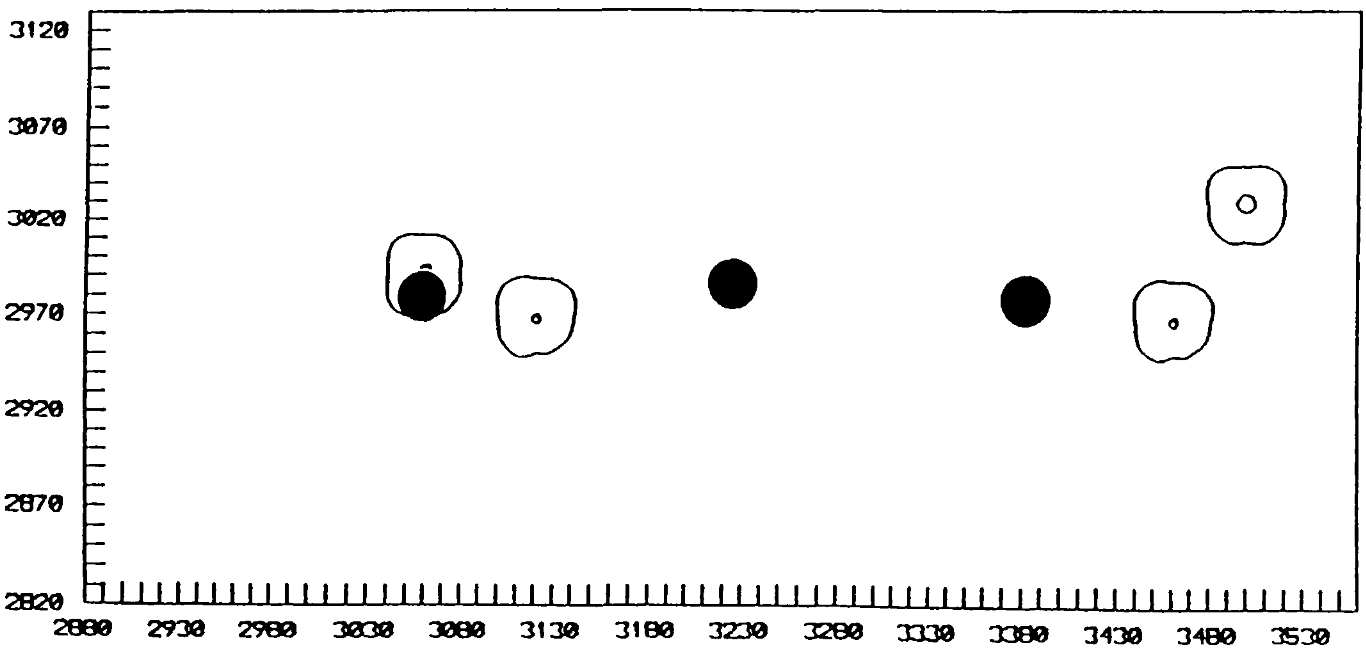
DAY 276 VERT. WELL LAYER 2 CONCENTRATION (ug/l)

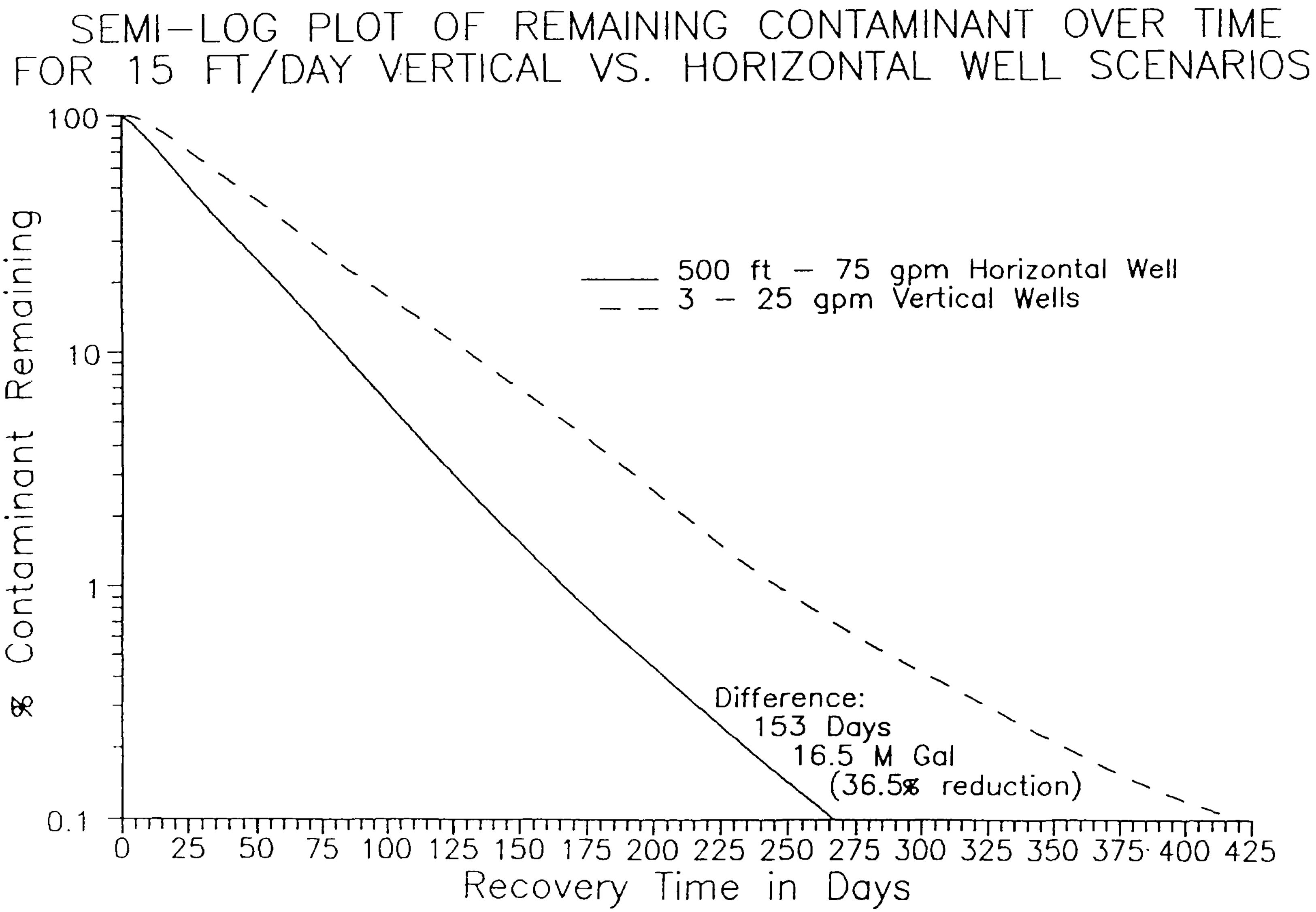


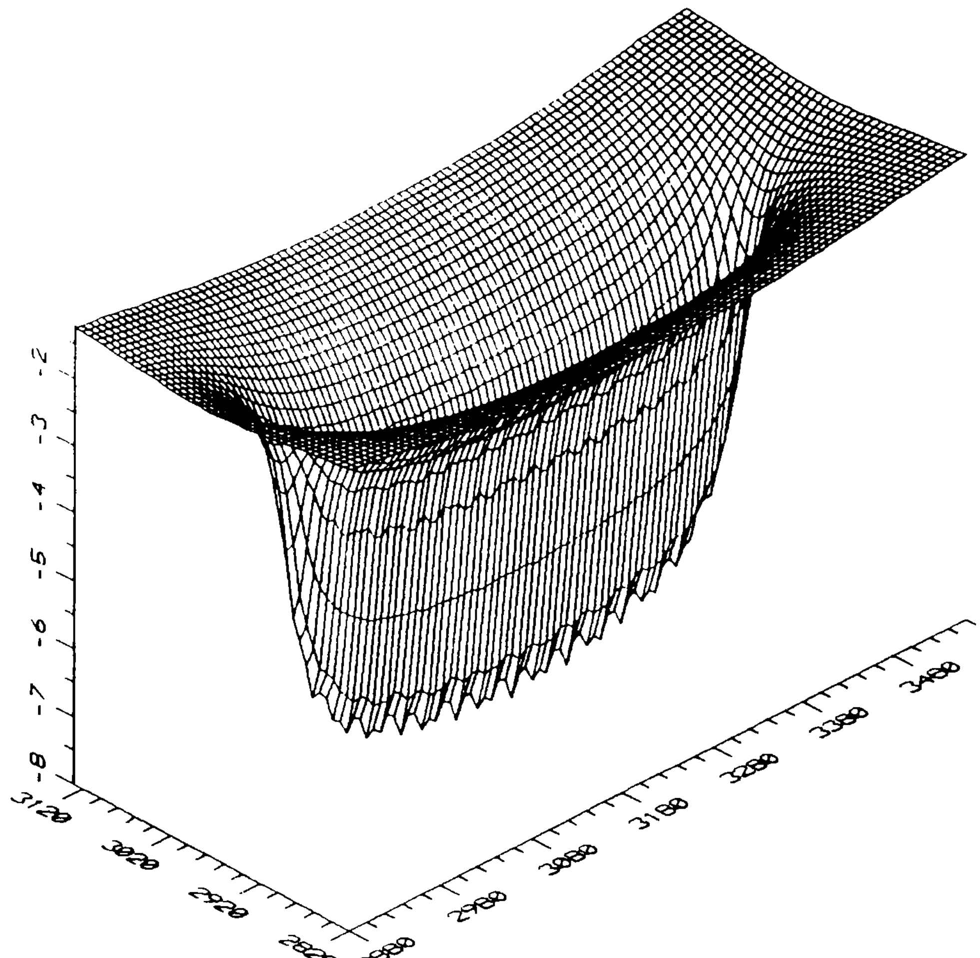
DAY 421 VERT. WELL LAYER 1 CONCENTRATION (ug/l)



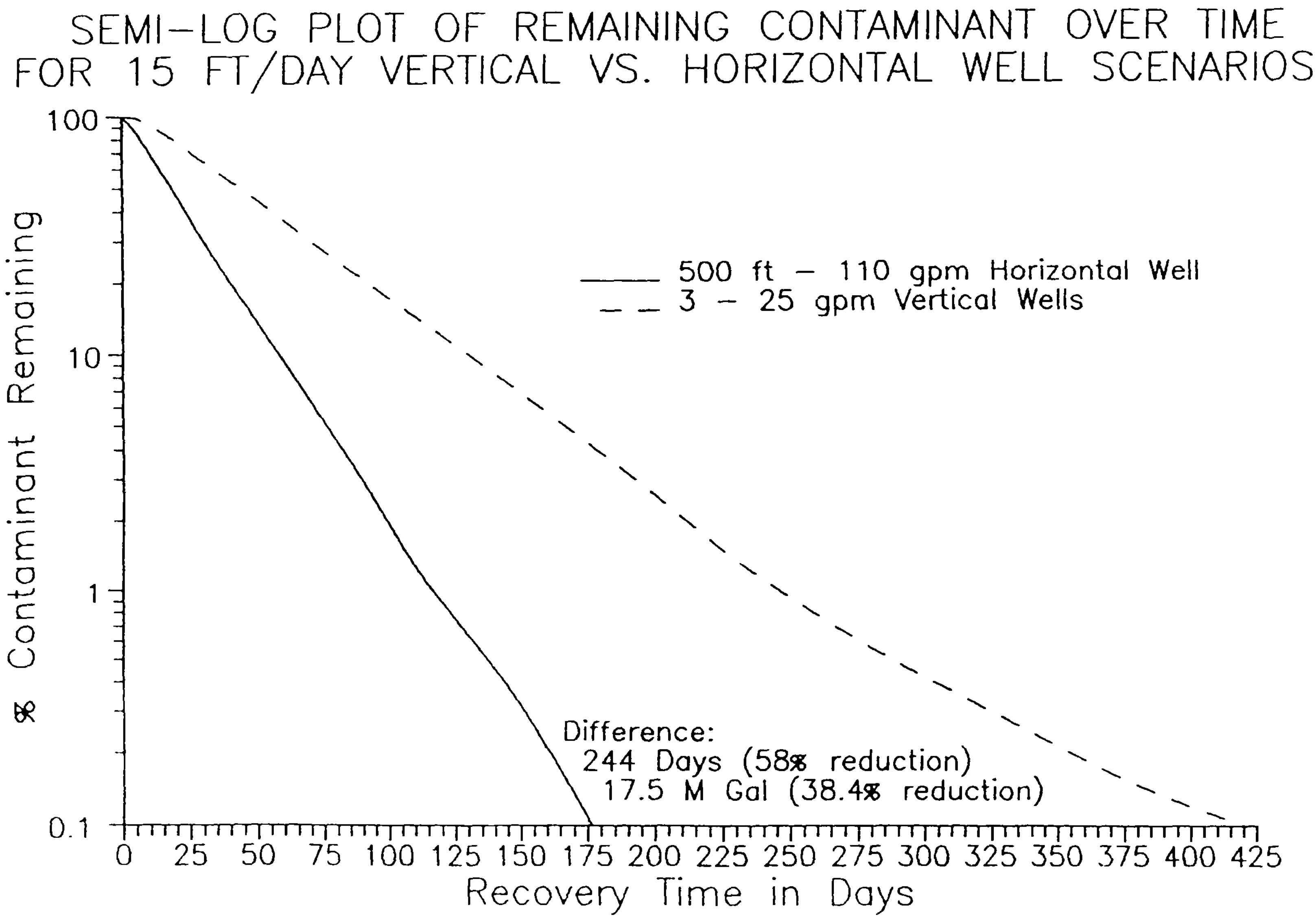
DAY 421 VERT. WELL LAYER 2 CONCENTRATION (ug/l)




SEMI-LOG PLOT OF REMAINING CONTAMINANT OVER TIME
FOR 15 FT/DAY VERTICAL VS. HORIZONTAL WELL SCENARIOS
500 ft - 75 gpm Horizontal Well
3 - 25 gpm Vertical Wells
Difference:
153 Days
16.5 M Gal
(36.5% reduction)
% Contaminant Remaining
Recovery Time in Days
100
10
1
0.1
0
25
50
75
100
125
150
175
200
225
250
275
300
325
350
375
400
425



110 GPM LAYER 1 HORIZONTAL WELL DRAWDOWN PLOT



SEMI-LOG PLOT OF REMAINING CONTAMINANT OVER TIME
FOR 15 FT/DAY VERTICAL VS. HORIZONTAL WELL SCENARIOS
500 ft - 110 gpm Horizontal Well
3 - 25 gpm Vertical Wells
Difference:
244 Days (58% reduction)
17.5 M Gal (38.4% reduction)
% Contaminant Remaining
100
10
1
0.1
0
25
50
75
100
125
150
175
200
225
250
275
300
325
350
375
400
425
Recovery Time in Days

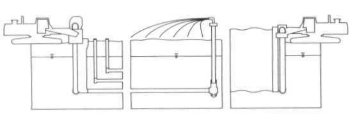
Summary of Horizontal and Vertical Well Modeling

- ▲ Increases Effectiveness of Contaminant Recovery
- ▲ Reduced Cleanup Time
- ▲ Lower Volume of Extracted Groundwater
- ▲ Limited Vertical Extent of Contaminant Movement

5

Polywall
BARRIER SYSTEM

HORIZONTAL TECHNOLOGIES INCORPORATED



Subsurface Environmental Control

*Horizontal Technologies, Inc. (HTI) proprietary **Polywall Barrier System** has been successfully installed to cut off the migration of diesel fuel into the Little River in Star Lake, New York. The **Polywall** will be used in conjunction with a **Linear Contaminant Remediation System** to recover free product and control groundwater flow. The system was installed continuously along the river bank for a distance of 1,350 lineal feet to depths of 15 feet below ground surface with water table-free product interface at an average depth of four feet.*

The Polywall Barrier System consists of equipment and materials that place continuous sheets of 40 to 100 mil High Density Polyethylene (HDPE) geomembrane vertically to depths of 30 feet and greater. Virtually any length or configuration of Polywall can be installed without concern over possible holes or windows inherent in other subsurface cutoff-containment structures.

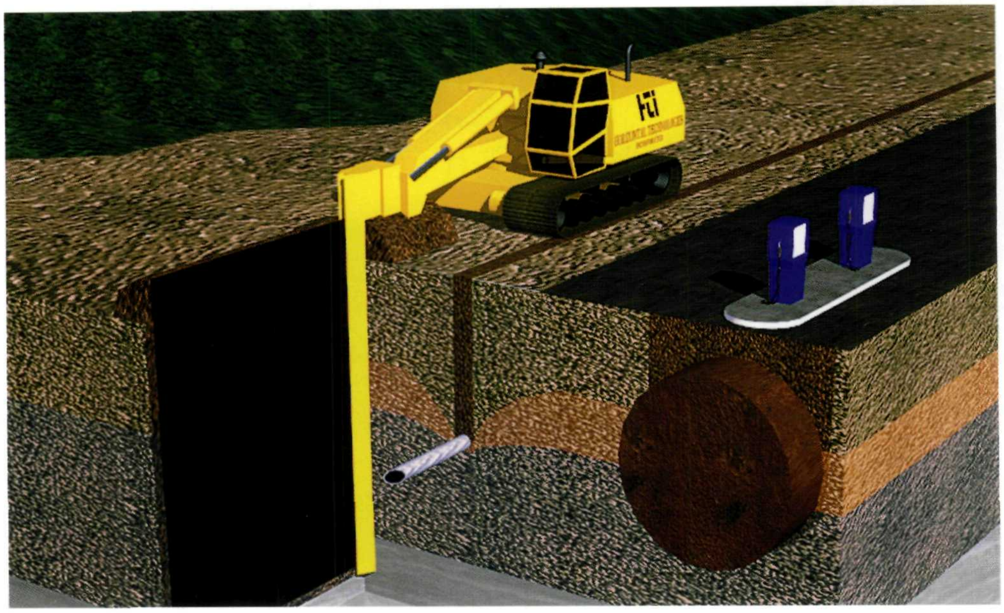
The HDPE geomembrane is manufactured by National Seal Company using virgin, first quality, high molecular weight polyethylene specifically formulated to be most resistant to sunlight, chemicals, toxic wastes and hydrocarbons. Sheets are joined together using a high performance, hydrophilic interlocking waterproof joint system that provides exceptional strength and environmental properties. These joints are not only impervious to fluids at initial installation but remain fluid tight for the life of the barrier.

This system can be combined with HTI's Linear Contaminant Remediation System (LCRS) and a wide variety of other in-situ and above-grade remediation systems. Other potential uses include prevention of leakage through levees, isolation of wetlands and sensitive areas, control of groundwater flow, and a wide variety of civil and hydraulic engineering applications.

Polywall
BARRIER SYSTEM

U.S. PATENT
No. 5,118,230

Other patents pending



This innovative subsurface environmental control technology, POLYWALL BARRIER SYSTEM, developed by Horizontal Technologies, Inc., offers a number of unique features over other types of cutoff and containment walls.

- state-of-the-art construction and rapid installation make it ideal for emergency response applications
- lower cost than conventional techniques
- maintenance-free, long service life
- installed in continuous sheets of 40 to 100 mil thickness in a 14-inch-wide trench
- interlocking waterproof joint system with hydrophilic joint sealant that can be visually inspected
- can accommodate irregular geometries/topographies
- extremely effective in controlling subsurface environments through isolation, containment and/or separation

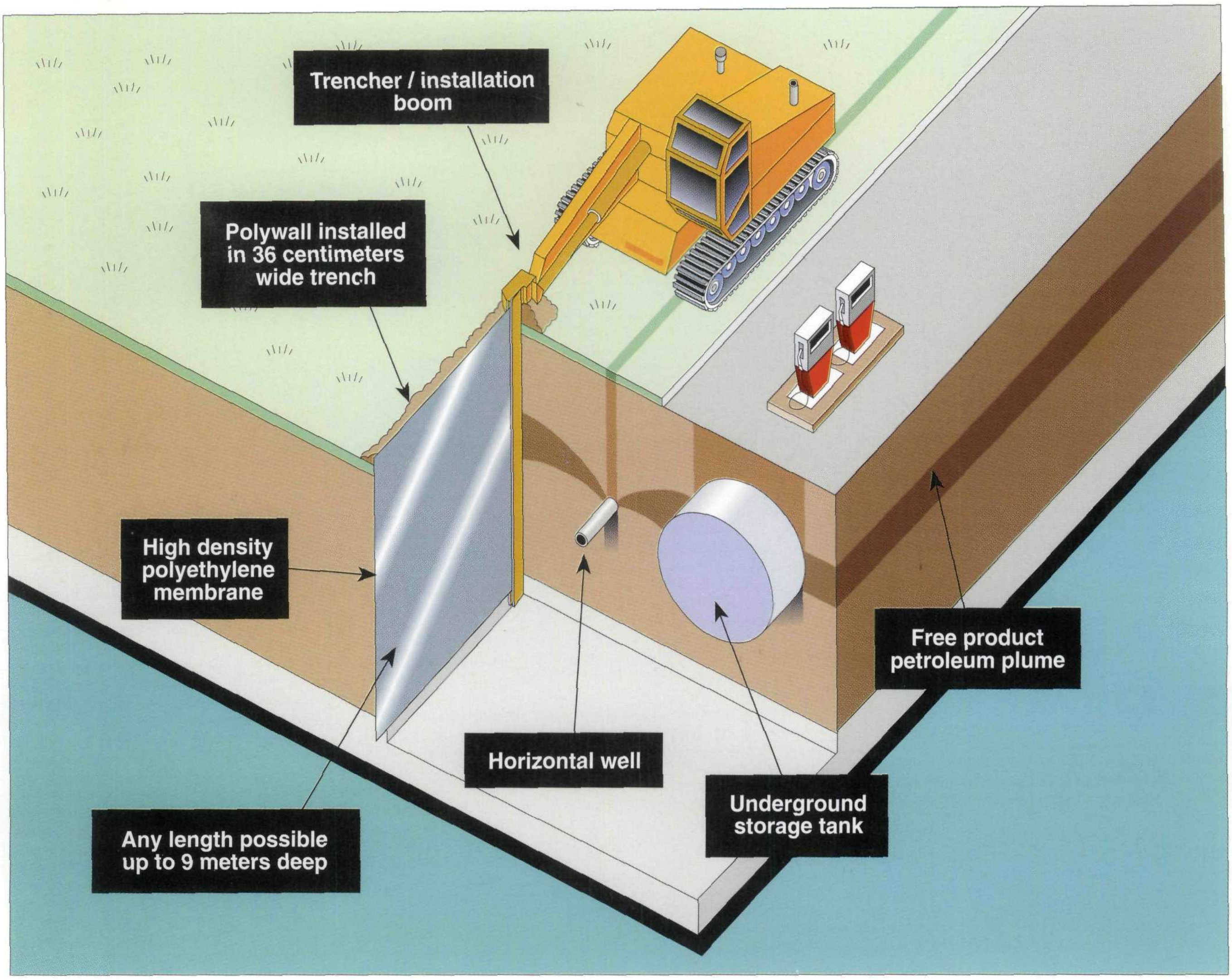
- compatible with HTI's LINEAR CONTAMINANT REMEDIATION SYSTEM (LCRS) for groundwater capture and control and contaminant removal
- can be used with in situ treatment technologies such as physical, chemical and biological reactors

HORIZONTAL TECHNOLOGIES INCORPORATED

OUR NEW ADDRESS IS:
HORIZONTAL TECHNOLOGIES, INC.
4767 Pine Island Rd., NW
Matlacha, Florida 33993
Phone: (941) 283-5640 • Fax: (941) 283-2222

HERE'S HOW IT WORKS...

Horizontal Technologies Polywall Barrier System



● Horizontal Technologies, Inc., Cape Coral, Fla., has developed a proprietary subsurface control system to install an impermeable barrier wall. The Polywall Barrier System places a continuous sheet of 40 to 100 mil high density polyethylene membrane vertically to depths up to nine meters below grade. The barrier is installed in a 36 centimeter wide trench, which minimizes generation of excavated soils. The wall can be extended to virtually any length because seams in the liner are joined in an interlocking waterproof tongue-and-groove system, says the company. The joints are heat welded to each end of the membrane above ground. Then the membrane is inspected and rolled up for installation. The installation machine can install liner at rates up to 20 meters per hour, depending on soil type and installation depth. Rolled liner is unfurled in the trench by a system of rollers and restraints. Backfill is immediate, making this a one pass system. Roll lengths vary depending on the thickness of the membrane being used; 40 mil thickness can be up to 60 meters long. Joints are sealed below grade with a hydrophilic polymer and can be visually inspected before backfilling. When consolidated stratum is encountered, a pretrenching pass is backfilled with sand before the installation pass. The barrier can control groundwater flow, isolate wetlands and prevent leakage through levees. It can also be used to create an in situ bioreactor for controlled treatment with the company's Linear Contaminant Remediation System (LCRS), a series of trenched, sand or gravel packed horizontal wells. At a site in Star Lake, N.Y., Polywall was installed with the LCRS along 400 meters of the Little River to a depth of 4.5 meters to prevent a diesel fuel plume from entering the river, and recover free product.

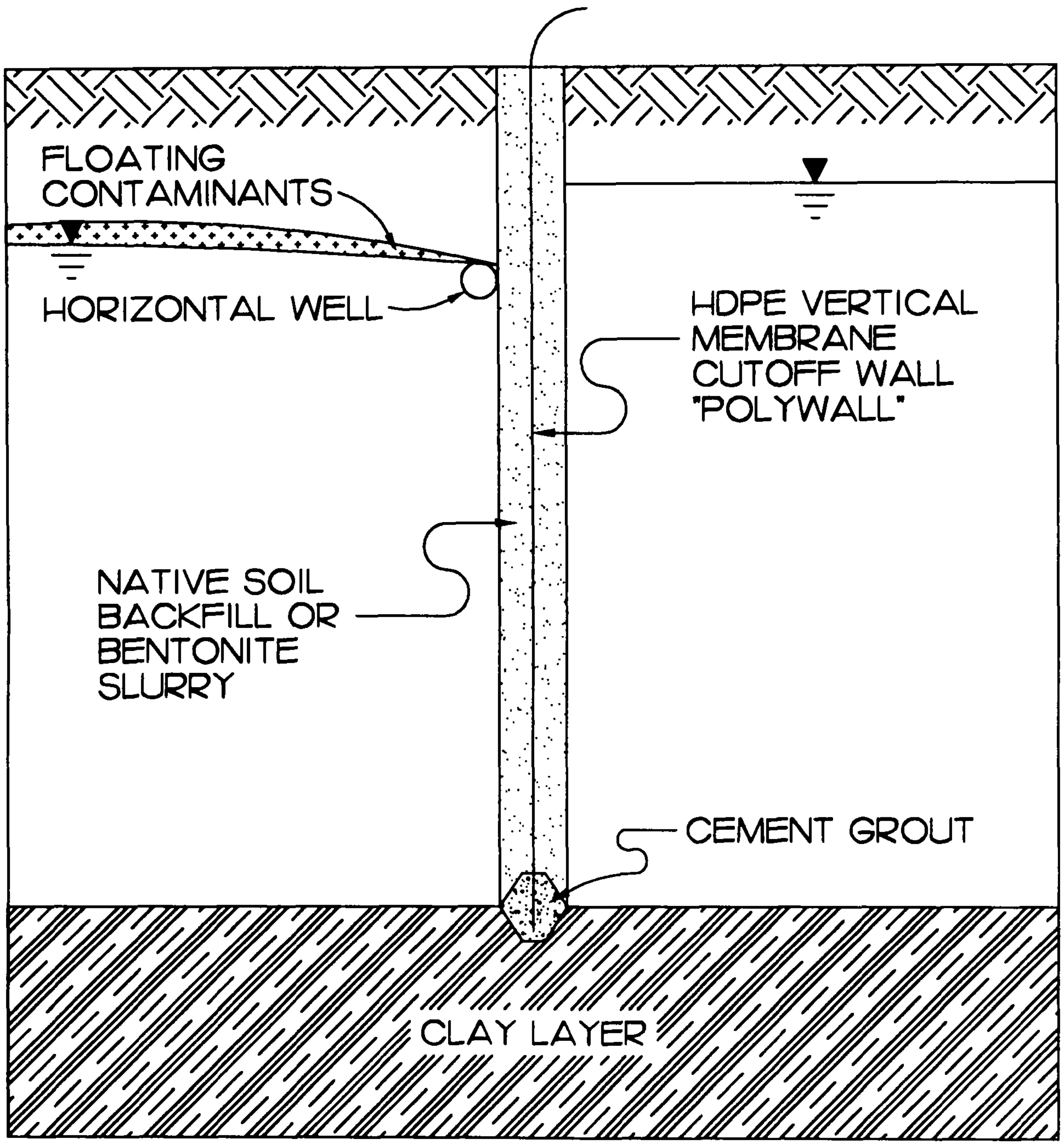
Citgo Asphalt Refinery - Savannah, GA

Horizontal Technologies recently completed the installation of its proprietary Polywall Barrier System at the Citgo Asphalt Refinery in Savannah, GA. The plant is located on the Savannah River, and its site has been used by industry since the early part of the century and during World War II served as a dry dock facility for the Navy. The site had become suspect of discharging LNAPL's into the Savannah River at intervals and had received the attention of the Coast Guard and other agencies concerned with the cleanup of the nations' waterways. DNAPL's were also present and posed part of the problem. The site was under lain by silty sands down to 15' with a clay layer beginning at this depth and extending to forty feet or more. Citgo chose Polywall for this project over other technologies because this system provided the most economical answer to this problem while offering as side benefits the best and quickest cutoff options. The wall was placed at a depth of twenty feet BGS and extended some eleven hundred feet along the river interface with two 100' returns on each end, providing fifteen hundred feet of continuous coverage. Interlocking self-sealing joints were placed at 180 foot intervals allowing construction of the continuous wall with only seven joints. Scheduling was critical because of other construction taking place that could not be interrupted. The site had an inordinate amount of below-ground utilities that had to be worked around, and extensive exploration of the Polywall path and preparation of the site prior to construction provided an in-place wall with only thrirteen days of actual construction time. Even though the water table was fluctuating and at high tide was only three feet below ground surface, the installation was made without dewatering. Special construction techniques also minimized the amount of contaminated material that had to be handled. The wall was constructed of forty mil high-density polyethylene manufactured by National Seal. The fast track project took less than thirty days from contract signing to job completion, and was finished ahead of schedule and within contract price.

CITGO REFINERY – SAVANNAH, GA

CITGO REFINERY - SAVANNAH, GA

USE OF VERTICAL LINER SYSTEM FOR CONTAINMENT AND CAPTURE OF FLOATING CONTAMINANTS



HTI	Horizontal Technologies, Inc. P.O. Box 150820 Cape Coral, FL 33915	PROJECT:		
		TITLE: LCRS-Polywall		
		This material is the property of HTI. Any reproduction or use of this material requires express written consent from HTI.		
		DRAWN BY:	DATE: 1/24/94	PLATE: REM13

POLYWALL BARRIER SYSTEM
HIGH DENSITY POLYETHYLENE GEOMEMBRANES

SPECIFICATIONS

1.0 These specifications describe the POLYWALL High Density Polyethylene (HDPE) geomembranes. The supply and installation of these materials shall be in accordance with these specifications and the contract drawings.

1.01 Geomembrane shall be manufactured in the United States or Canada to allow for plant inspection.

1.02 The manufacturer shall be listed by the National Sanitation Foundation as having met standard 54 requirements for flexible membrane liners.

2.0 Description

2.01 **Manufacturing Process** - The manufacturing process shall be controlled by a fully computerized control system that continuously monitors sheet thickness at check points across the width and length of each roll.

2.02 The HDPE geomembrane shall be manufactured from first quality virgin, high molecular weight resin produced in the United States or Canada specifically for the purpose of hydraulic containment. Blending of resins will not be allowed. Edge trim generated during the manufacturing process for the geomembrane may be continuously returned to the base resin provided it not exceed 2% of the product. No other recycled or reworked resin may be used.

2.03 The resin used to product the geomembrane shall be formulated to be resistant to chemical and ultraviolet degradation.

2.04 The geomembrane shall be free of plasticizers and other leachable additives.

2.05 The manufacturer shall test the base HDPE resin to ensure the consistency and quality of the raw material. Each batch shall be tested for the following properties:

Density
Melt Flow Index
Volatiles Content
Oxidative Induction Time

2.06 **Thickness** - Each roll shall be continuously monitored across the width of each roll to assure uniformity of thickness. At no point shall the thickness of the roll be more than 5% below the specified nominal material thickness.

2.07 **QC Testing** - All geomembranes shall be tested in accordance with the Manufacturer's Quality Control Manual. The following tests are to be performed at least once every 50,000 square feet of line.

TEST	
Thickness	Density
Tensile Properties	Constant Load ESCR*
Carbon Black Content**	Dimensional Stability
Carbon Black Dispension	

*Constant Load ESCR tested once per batch
**On sheet manufactured from natural resin and carbon black concentrate and on fully compounded resin tested every 45,000 lbs.

2.08 The geomembrane must be shipped free of any factory seams, unless otherwise provided for.

2.09 Geomembrane shall be shipped and stored in rolls, not folded.

3.0 The geomembrane shall be 40-100 mil High Density Polyethylene as manufactured by National Seal Company or an approved equal. The geomembrane shall conform to the properties detailed below. All values are Minimum Average Roll Values* unless otherwise noted.

4.0 Manufacturers Statement

4.01 Upon request, the manufacturer shall submit a certification signed by its authorized representative indicating that the material meets the manufacturers specifications.

4.02 Each roll of geomembrane shall be labeled with the following information.

1) Product Identification
2) Roll Number
3) Roll Thickness
4) Roll Dimensions
5) Resin Type
6) Date of Manufacture

5.0 Installation

5.01 Geomembrane material shall be shipped and stored by appropriate means so that no damage is caused to the material. Material shall be stored in a secure area so as to protect it from standing water, soil, theft and vandalism.

5.02 The POLYWALL installation contractor shall be responsible for preparing and maintaining the subgrade surface, trenches and anchors in a condition suitable for the laying of geomembrane.

5.03 A linear panel layout shall be provided prior to installation which will indicate the general configuration intended by the POLYWALL installer.

5.04 As-built POLYWALL drawings indicating any changes to the layout drawings shall be available upon request.

5.05 The trenching method and equipment used to deploy the POLYWALL shall not damage the geomembrane or the supporting subgrade surface.

5.06 Wrinkles shall be minimized.

5.07 All personnel performing seaming operation shall be trained in the operation of the specific seaming/jointing equipment being used.

5.08 Double wedge fusion welding, when applicable, shall be the primary welding procedure. Extrusion welding will only be used for repairs and detail work, such as affixing special joint/seam seals.

5.09 Installer shall be responsible for determining whether seaming/jointing should be restricted or halted due to weather conditions.

5.10 Fusion and extrusion welding shall be performed in accordance with the installer's field manual.

5.11 Extrusion rod should be the same type of resin as the geomembrane.

5.12 The POLYWALL Barrier System shall be installed continuously along lines and grades as established on the contract drawings or in accordance with installer's linear layout as provided for in **5.03** hereof.

5.13 The installation of the POLYWALL Barrier System shall be by a trenching machine that is designed to excavate the trench area in a width of 14" $\pm$, to specified depths and grades, plus install the HDPE vertically and simultaneously with the excavation process, from the ground surface to the appropriate depth. The installation machine and delivery equipment for the POLYWALL Barrier System shall be as designed by Horizontal Technologies, Inc. of Cape Coral, Florida and installed in accordance with their recommendations.

5.14 The installer shall submit an installation and trencher operation plan which will include control and adjustment procedures to establish and maintain lines and grades during placement, inclusive of a sequence of pavement removal, pavement removal widths, trench widths, pretrenching and workplace requirements, plus utility relocations that may be applicable.

5.15 Backfill and/or filter materials placed in the trenchline adjacent to the POLYWALL Barrier System shall be graded so as not to injure or disturb the HDPE and preserve the grain size distribution to prevent voids during the placement. The backfill and/or filter materials shall be as specified or as recommended by the installer.

5.16 The joint system will be interlocking and waterproof and will include two hydrophilic joint seals that can be visually inspected after joining. Minimum distance between joints shall be sixty feet, except as required in return connections.